# *A Geological Reconnaissance of Bland, Giles, Wythe and portions of Pulaski and Montgomery Counties of Virginia.*

*By John J. Stevenson, Professor of Geology in the University of the City of New York.*

(*Read before the American Philosophical Society, March 18, 1887.*)



## INTRODUCTION.

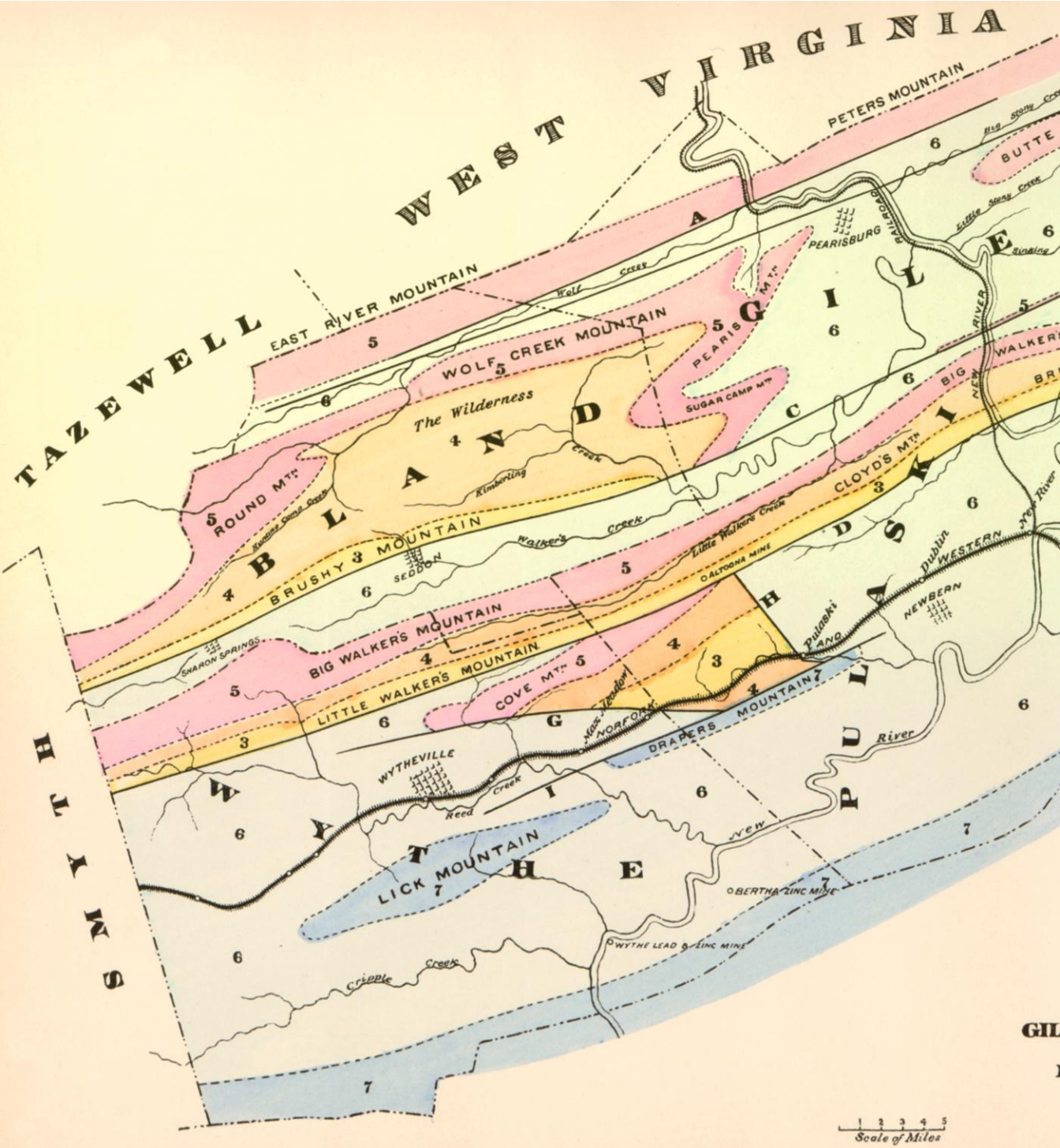
The region described in this memoir, embracing Bland, Giles, Wythe and portions of Pulaski and Montgomery counties of Virginia, is the eastward continuation of the region described in the writer's previous memoirs* on the geology of Southwestern Virginia.

The examination of the area under consideration was purely a reconnaissance, and the notes in several localities must be regarded as little more than suggestions to the one who may make the detailed study on behalf of the United States Geological Survey.

The whole area is rugged. Even the Great valley, so wide in Washington and much of Smyth county, becomes broken in Wythe by the introduction of Potsdam ridges south from the railroad, while a new fault originating in Wythe county reproduces Big and Little Walker mountains in Cove and Max Meadows mountains north from the railroad. These break the valley in Pulaski county also, while the faults of Price mountain hold between them a Carboniferous area, which divides the valley in Montgomery county from New river almost to the line of Roanoke county. The whole region from the Tennessee line north-eastward to beyond the New river, as far as the writer has gone, is broken by successive pairs of Silurian and Devonian mountains separated by valleys of Lower Silurian limestone.

The Walker mountains, Big and Little, originating in Smyth county, are continuous to beyond the eastern border of Montgomery county. The latter ridge changes its name twice, becoming Cloyd's mountain as it approaches New river and Brush mountain beyond that stream; while the former retains its name to the river and thence becomes Gap mountain. Big Walker maintains its rugged features throughout and shows but two water-gaps, those made by Walker's creek and New river, which are separated by barely seven miles. Some wind-gaps exist, one of which, near

* These were read before this Society and are to be found in the Proceedings, Vol. xix, pp. 88 to 107, 219 to 262, 498 to 505; and Vol. xxii, pp. 114 to 161.


WEST VIRGINIA
TAZEWELL
SMYTH
WYTHE
PULASKI
GILES
BLAND
PETERS MOUNTAIN
EAST RIVER MOUNTAIN
WOLF CREEK MOUNTAIN
The Wilderness
PEARIS MTN
SUGAR CAMP MTN
ROUND MTN
BRUSHY MOUNTAIN
BIG WALKER'S MOUNTAIN
LITTLE WALKER'S MOUNTAIN
COVE MTN
CLOYD'S MTN
DRAPERS MOUNTAIN
LICK MOUNTAIN
BUTTE
PEARISBURG
SHARON SPRINGS
SEDDON
WYTHEVILLE
NEWBERN
ALTOONA MINE
BERTHA ZINC MINE
WYTHE LEAD & ZINC MINE
Wolf Creek
Walker's Creek
Little Walker's Creek
Kimberling Creek
Reed Creek
Cripple Creek
New River
Big Stony Creek
Little Stony Creek
Norfolk & Western
Dublin
Pulaski
Max Meadow
Scale of Miles
1 2 3 4 5


# GEOLOGICAL MAP OF
# GILES, BLAND & WYTHE COUNTIES
WITH PARTS OF
# PULASKI & MONTGOMERY COS.,
# VIRGINIA.

by J. J. Stevenson.

1886.

the west line of Wythe county, is thought to be available for a railroad line. Water-gaps through Little Walker are numerous, but with one exception they have been made by streams rising in the valley between the mountains or on the southerly slope of Big Walker. New river alone has made a continuous gap through both ridges. The ruggedness of Big Walker is due partly to the refractory nature of the Medina which forms its body, but more to the steep dip, which makes the mountain narrow and limits the effectiveness of erosion. The rocks of Little Walker are more easily affected by atmospheric agencies, and for the most part they have a much gentler dip.

The Clinch Mountain group, so conspicuous in the counties previously described, comes to an end in Giles county under the influence of two anticlinals and of extensive erosion on both sides of New river. The Medina outcrop, doubling over the anticlinals, forms Pearis and Sugar Camp mountains, while the Brushy mountain of Chemung and Vespertine disappears very near the line of Bland and Giles counties. But beyond New river the anticlinals diminish and the group reappears in the magnificent pile of Butte and Salt Pond mountains, the latter rising to fully 4500 feet above tide. These mountains extend eastward into Craig county, and are conspicuously visible from localities beyond Little Walker. Wolf Creek mountain, originating in Tazewell county as a loop of Clinch mountain, extends to Pearis mountain and thence is continuous with the others. The Garden mountains unite to form the anticlinal ridge of Round mountain, which gradually disappears in the broad space between Wolf creek and Brushy mountains, known as "the wilderness."

East River mountain, originating in Tazewell county, retains its name to New river, beyond which it becomes Peters mountain. Like the other Medina ridges, it is rugged and almost unbroken, the only water-gap for many miles being that of New river.

The mountains, Cove and Max Meadows, in Eastern Wythe and Western Pulaski, are short, being cut off at each end by a fault. The area occupied by them is comparatively rugged and imperfectly cleared, so that little examination was made of it. Lick mountain is about fifteen miles long and is wholly within Wythe county. It lies south from the railroad, is abrupt and almost uncleared. Draper's mountain, somewhat further east, is in both Wythe and Pulaski, and is even more rugged than Lick mountain, while its length is approximately the same. Price mountain, in Montgomery county, north from the railroad, is a short, by no means abrupt ridge, which extends from New river eastward for say eight miles, and attains its maximum at about five miles from that river.

The whole region, aside from the south-west corner of Bland county, is drained by the New river and its tributaries. That great stream rises on the Atlantic side of the Blue Ridge and flows across every fold of the great Appalachian chain until, as the Kanawha, it enters the Ohio at Point Pleasant. Its most important tributaries here are Reed and Cripple creeks in Wythe; Big and Little Reed Island, Peak and Back creeks in

Pulaski; Walker, Wolf and Sinking creeks in Giles. Most of these streams carry much water, and for a large part of the year afford power for mills; but the water-supply is not so regular as it was before so much clearing had been done, and floods are now too frequent. The New river, however, carries a large volume, and mills along its banks rarely suffer inconvenience.

Agriculturally the features of this region do not differ from those of the area already described, except that, as already indicated, the proportion of rich land is much less. The limestone areas are those indicated on the map by the number 6, all the other portions are sandstone or shale. Much of the sandstone region is abrupt or so rugged as to be worthless for ordinary farming purposes, but much of the shale land lies so well for cultivation that one feels more than regret because it is so thin. In seasons when the "rich" valleys yield twenty-five to thirty bushels of wheat, the "poor" valleys yield only from seven to ten bushels. The limestone areas are admirably adapted to grazing, as the grass is abundant and nutritious. The stock interests are extensive, and the cattle bring the highest price in Baltimore, Philadelphia and New York markets.

As the area described in this memoir does not reach to the West Virginia coal measures at the north, it offers a somewhat shorter list of mineral resources than do the areas previously examined. Clinton ore occurs on Big Walker, Round, Wolf creek and others of the Medina mountains, while brown hematite occurs on the southerly slope of those mountains and to some extent in the Lower Silurian limestones north from the Norfolk and Western railroad; but nothing is known positively respecting either the quantity or the quality of these ores. Brown hematite, zinc, lead and manganese ores occur abundantly in the southern part of Wythe, Pulaski and Montgomery counties, where the production of iron, zinc and lead has long been important. Little has been done toward developing the manganese. Coal occurs in the Vespertine along Brushy mountain in Bland county; Little Walker in Wythe, Pulaski and Montgomery; in the Peak hills of Wythe and Pulaski; and in Price mountain of Montgomery. It has been mined to a greater or less extent at several localities in Pulaski and Montgomery. Not a little good timber remains, but the charcoal burner at the south and the portable saw-mill at the north have done much destruction without bringing much profit to the owners.

The only outlet to market is by the Norfolk and Western railroad with its New River branch to the Pocahontas mines, seventy-six miles long, and the Cripple Creek branch from Pulaski to the rich mineral region of Southern Pulaski and Wythe counties. The topography renders construction of railroads difficult and costly, and the only easy line northward from the valley is occupied by the New River branch of the Norfolk and Western; but an available route is said to exist from Wytheville over Walker mountain near the Wythe and Tazewell pike. As the mountains are in pairs a promising water-gap in one usually leads to an impracticable crossing of the other, and the railroad engineer often finds his wits of

little service. Many routes have been surveyed in these and adjoining counties, and each new survey is an object of much interest. Some additional railroads would be an undoubted convenience, as, except the pike connecting the county towns of the Great valley, the roads are not macadamized, and the amount of labor expended on them clearly does not exceed the minimum required by law.

Those portions of this area which are underlaid by limestone are cleared and for the most part are under cultivation ; but the other portions have comparatively few settlers and are traversed by roads usually not fit for light vehicles. As a rule the people are prosperous, utilizing the advantages which are available, while they waste little of their energies in discussing the value of the mineral wealth, which is of no immediate importance away from the Great valley. The villages in the valley are thrifty, have good church buildings and are well supplied with schools. The hamlets in Bland and Giles counties are very small and have little to support them.

*Lists of Altitudes.*

Mr. W. W. Coe, of Roanoke, Va., Chief Engineer of the Norfolk and Western railroad, has kindly given me the following list of elevations above tide :

*On main line.*

| | |
|---|---|
| Crocketts | 2327 |
| Wytheville | 2230 |
| Max Meadows | 2015 |
| Pulaski | 1904 |
| Dublin | 2058 |
| New River | 1768 |
| Central | 1773 |
| Christiansburg | 2007 |
| New River Bridge | 1760 |

*On New River Branch.*

| | |
|---|---|
| Belspring or Churchwood | 1766 |
| Summit cut, 2½ miles from New River | 1914 |
| Staytide | 1640 |
| Ripplemeade | 1607 |
| Wenonah | 1559 |

*On the river.*

| | |
|---|---|
| Mouth of Walker's creek, about | 1570 |
| Mouth of Stony creek, about | 1555 |
| Thorn's ferry | 1950 |

Mr. Oramel Barrett, Jr., of Abingdon, Washington Co., Va., has given

me the following list of elevations of points on Clinch and Holston rivers, on the line of the proposed Clinch River railroad.

| | |
|---|---|
| Mouth of Thompson's creek | 1518 |
| Mouth of Weaver's creek | 1502 |
| Mouth of Dump creek | 1480.5 |
| Mouth of Bickley's Mill creek | 1447 |
| Mouth of Lick creek | 1442 |
| Mouth of Russell creek | 1413 |
| Mouth of Bull creek | 1399 |
| Mouth of Guest river | 1373 |
| Mouth of Little Stony creek | 1332 |
| Osborne's ford, about | 1284 |
| Railroad crossing at Dingus's | 1255 |
| Mouth of Big Stony creek | 1248 |
| Mouth of Cove creek | 1226 |
| Mouth of Stock creek | 1203 |
| Mouth of Copper creek | 1196 |
| Summit in "Big Cut," between Clinch and Holston | 1579 |
| Big Moccasin creek, below Estilville | 1241 |
| N. Fork Holston, at Holston Springs | 1185 |
| Same at mouth of Opossum creek | 1176 |
| Same at Virginia and Tennessee line | 1175 |
| Nash's ford, on Clinch, above five miles above mouth of Thompson's creek, about | 1542 |

Some of the elevations given in this list by Mr. Barrett, differ from elevations of the same localities, as published in a former memoir. The discrepancy is due to the acceptance of a wrong determination of the locality where the work began.

## I. THE FAULTS AND FOLDS

The Clinch River group of faults, including the New Garden, Stone Mountain and Abb's Valley, lie north from the area under consideration. They gradually diminish eastward in Mercer county, of West Virginia, and it is doubtful whether they pass in any case much beyond the line into Summers county, of the same State. Nothing further north than the edge of the House and Barn synclinal of the last paper was reached during this reconnaissance.

The geological structure of the southern part of this area is not unknown. Two sections were made by members of the Geological Corps, under W. B. Rogers, one passing through the eastern part of Wythe and Bland counties, the other through Roanoke and Craig counties, at a few miles beyond the eastern limit of the writer's study. Prof. Rogers, in his report of 1838, gave a summary account of the Vespertine coal areas. Prof. Lesley* published notes on the geology of Wythe, Pulaski

*Proc. Amer. Phil. Soc., Vol. ix, p. 30 et seq.

and Montgomery, and Prof. Fontaine* has given interesting details respecting the Vespertine coals. Mr. C. R. Boyd, of Wytheville, Va., has published a work, dealing with the economics of South-west Virginia, in which are given many geological details, with a map which topographically is a very notable improvement on its predecessors. The writer is under obligations to these publications which will be acknowledged in the proper connection.

The general type of structure is practically the same as that found in the areas already described, and it has been well represented by Lesley, who in his memoir on Tazewell county,† gives an ideal figure, which with his permission is reproduced as Fig. 1. The upthrow side, except in the case of cross-faults, is the south-east, and the Lower Carboniferous is found for greater or less distances in contact with the Lower Silurian limestones along most of the fractures. These faults are not simple, as is well shown in the Clinch group, but subordinate and cross-faults do not appear to arise directly from those of the principal system; and wherever a fault, either principal or subordinate, was followed out, it was found to originate or to terminate in an anticlinal. The faults are not parallel, they bear no relation whatever to the folds except such as is purely fortuitous, and their direction is wholly independent of the strike. A regular fault such as the Saltville exhibits this well, the upthrow group being in contact with different groups at different localities, owing to the influence of anticlinals on the downthrow side. Some interesting facts of this kind were given in the previous memoirs; others will be given in this, going to show independence of the faults and the folds and, as the writer intimated several years ago, suggesting very strongly a difference in age.

The structure is hardly so simple as that of the counties already described and the description cannot be given in so direct a manner as that of the other counties.

*The Lick Mountain Anticlinal.*

Lick mountain, at a little way southward from the railroad in Wythe county, is due to a strong double anticlinal, which diminishes rapidly eastward and is soon recognizable only as a gentle fold, followed by the Valley pike north-eastward for six or seven miles in Pulaski county. It was not traced beyond New river. How far westward it can be traced in Smyth county was not ascertained. It brings up the Potsdam in Wythe county, so as to form a very rugged mountain about fifteen miles long, but eastward it sinks so as to be crossed by the Knox shales before Reed creek has been reached; thence, as far as it was followed, no beds below the Knox shales are shown on the axis.‡ Some anticlinals in the Knox limestone were seen between the Lick mountain fold and the southern edges of Wythe and Pulaski counties, but they were not followed. One is crossed by the New river, very near the Wythe lead mine.

*Amer. Journ. of Science, Jan. and Feb., 1877.

†Proc. Amer. Phil. Soc., Vol. xii, p. 490.

‡The easterly limit assigned to these shales on the map is conjectural.

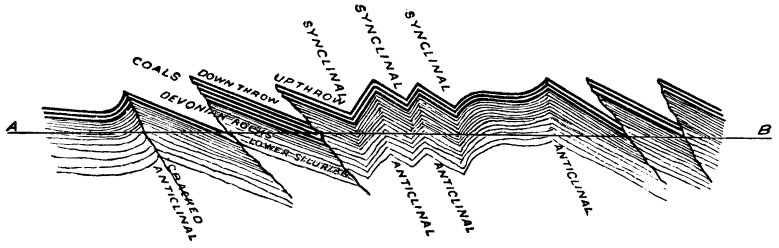



FIG. 1.—After Lesley; Ideal cross-section showing the downthrows.

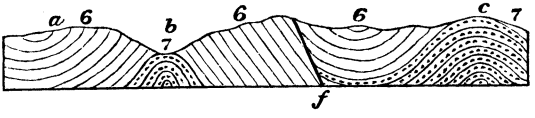



FIG. 2.—Section through Kent's Station on Norfolk and Western Railroad. *a*, Wytheville synclinal; *b*, Wytheville anticlinal; *c*, Lick Mt. anticlinal; *f*, Draper Mountain fault; 6, Lower Silurian; 7, Cambrian.

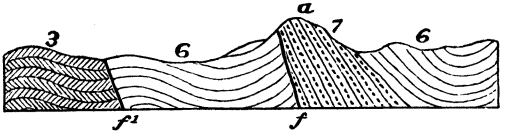



FIG. 3.—Near line between Wythe and Pulaski counties. *a*, Draper Mt.; *f*, Draper Mt. fault; $f^1$, Max Meadows fault; 3, Lower Carboniferous; 6, Lower Silurian; 7, Cambrian.

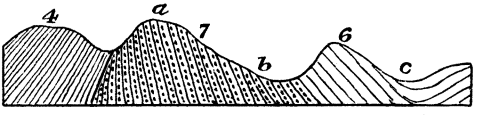



FIG. 4.—On Pulaski road. *a*, Draper Mt.; *b*, Draper Valley; *c*, Macadam road; *f*, Draper Mt. fault; 4, Devonian; 6, Lower Silurian; 7, Cambrian.

*The Fault of Draper Mountain.*

At a mile and a half, or perhaps a little less, south from Reed creek on the road leading from Wytheville southward over Lick mountain, the Knox Limestones are much disturbed, being thrown into several close folds. On the Valley pike, probably a mile and a half from the first crossing of Reed creek, the upper limestones of the Knox are succeeded by red shales belonging at the base of the group; the fault rapidly develops and passes along the northerly side of Draper mountain, where it brings the lower beds of the Potsdam at the south into contact with the base of the Lower Carboniferous, and further eastward with the Chemung. It quickly diminishes eastward and soon is in the Knox limestone. An anticlinal is crossed by the Valley pike very near Newbern; it may represent the fault.

The structure of this fault is fairly well shown at several localities, but the conditions are complicated for much of the distance by two cross-faults coming the one from the north-west and the other, if the map be right, almost from the north. A section on and near the Valley pike in Wythe county is represented by Fig. 2, but the section crossing Draper mountain near the line between Wythe and Pulaski counties, as represented in Fig. 3, shows a very different condition, for here the Max Meadows cross-fault is seen. The Knox limestones certainly describe an anticlinal near the fault, but whether or not they dip away at the fault could not be ascertained. The Potsdam forms the heart of this very rugged mountain and is dipping south-eastwardly at from thirty-five to nearly sixty degrees. Further east, where the road crosses Draper mountain to Pulaski, the structure is as given in Fig. 4. The structure is distinct along this road for the Devonian shales are turned up at the fault so as to be actually conformable in dip with the lower shales of the Potsdam. The exposures along this road in descending the mountain are practically continuous, yet it will be found difficult to determine accurately the place of the fault, so closely do the shales resemble each other and so nearly exact is the conformability of dip. In all probability, the Vespertine is brought into contact with the lower beds of the Potsdam at a short distance west from the road, so that this is the most formidable fault yet noticed. The Pulaski fault cuts off the Devonian and Carboniferous, and the Lower Silurian beds are on both sides of the fault beyond Peak creek.

*The Area between the Norfolk and Western Railroad and the Walker Mountain Fault.*

The village of Wytheville, county seat of Wythe, is built on a ridge marking the course of the Wytheville synclinal, which, beginning certainly more than six miles westward from Wytheville, extends east-north-east to where it is cut off by the Max Meadows fault north from Max Meadows station. A well-marked anticlinal bounds it on the southerly side, which is crossed by the Valley pike near Kent's mills, three miles

and a half from Wytheville, and it may be the same with that seen near Max Meadows on the railroad. It is crossed very near Reed creek on the Lick Mountain road. The dips in this portion are interesting. Within the synclinal ridge, composed of Knox Limestones, the dip is fifty to sixty degrees on both sides. The anticlinal brings up the Knox shales, which are shown on the railroad just west from Kent's mills. The south-easterly dip looking toward the Draper Mountain fault is at first very abrupt, being almost vertical for some distance along the pike, but it becomes gentler until the higher limestones have a dip of not more than twenty degrees.

The Max Meadows fault has its origin evidently in an anticlinal, which is crossed by the Wythe and Tazewell pike at say two miles and a half from the Wytheville borough line; it is crossed by Cove creek very near its forks and by the Norfolk and Western railroad at not far from three miles and a half beyond Max Meadows station. At a little distance further it must unite with the Draper Mountain fault. It cuts off the Wytheville anticlinal and synclinal at the east, while on the other side it cuts off a broad synclinal and an anticlinal which are well shown in eastern Wythe and western Pulaski and may be continuous with the Wytheville folds; but of this, one may not speak positively. The fault becomes greater as it extends south-eastwardly at an angle with the strike, so bringing Hudson, Medina, Clinton, Hamilton, Chemung and Vespertine successively into contact with the Knox limestones and shales on the opposite side.

The Pulaski fault, like the last, is a cross-fault and is the easterly boundary of the area of newer rocks held between the Walker Mountain, Max Meadows, Draper Mountain and Pulaski faults. The details of this fault were not worked out, but if the map employed be accurate, the direction from the Walker Mountain fault is almost south-south-east to Pulaski, where the course is changed to east-south-east. Evidently the line is south from Peak creek for more than two miles below Pulaski. Knox limestones are shown throughout on the easterly side of the fault, but on the opposite side are Devonian and Carboniferous rocks as far as followed. The region embraced within these faults was not worked out in detail, as much of it is not cleared; but it is evident that Cove mountain and its Devonian companion are monoclinals and there is every reason to suppose from the exposures along the railroad that an anticlinal exists in the Peak hills, the low ridge directly north from Pulaski. The limits assigned to the several groups within this area are largely conjectural.

The structure of Pulaski county east from the Pulaski fault is not shown satisfactorily along the roads, but cuts along the New River branch of the Norfolk and Western railroad make the structure clear. The Knox limestones are badly twisted for two miles and a half from New River station, but afterwards for nearly a mile they dip quite regularly to the north-west. The dip is reversed at three and a half miles and thence for a mile the pre-

vailing dip is south-east, though there are some reversals. The dip becomes very flexuous at four miles and a half, and the same beds remain in sight thence until near Belspring station, where all exposures cease. The structure may be regarded as representing two anticlinals with irregular crests, separated by a well-defined synclinal, whose axis is somewhat more than two miles south from Belspring station. The northerly anticlinal is cut off by the Walker Mountain fault.

The faults of Price's mountain east from New river in Montgomery county hold between them a fragment of an anticlinal, the Price Mountain area of Vespertine coals. Between the Walker Mountain fault at the north and the northerly fault of Price's mountain, the Knox limestones describe a synclinal, though the few and unfortunately somewhat indefinite exposures show that it is complicated. The lower beds of the Knox limestone are brought into contact with Umbral red shales, but whether they are dipping to or from the fault could not be ascertained. The limestone on the northerly side dips northwardly at fifteen to thirty degrees, while the Lower Carboniferous rocks beyond the fault are dipping in the same direction at thirty to fifty-five degrees, the rate increasing toward the summit of the Price's Mountain anticlinal. The dip is gentler on the southerly side of the axis, rarely exceeding twenty degrees. The conditions at the southerly fault were not clear at the only point where it was crossed, further than that the Umbral shales and the Knox limestones are in contact. The eastward extent of these faults was not ascertained. They do not appear to cross New river at the west.

*The Walker Mountain Fault.*

This fault, following the southerly foot of Little Walker mountain, enters Wythe from Smyth county and, at the county line, brings Knox limestone into contact with the Vespertine sandstones. The line of fault is crossed by Stony fork of Reed creek at somewhat more than six miles from Wytheville, its place being shown there by a narrow valley passing in front of the M. E. Church. The church is on Umbral shales, while Knox limestones crop out on the opposite side of the bottom. The conditions are the same in Crockett's cove, but in Pulaski county for several miles they are very different. There the Lower Carboniferous beds on the northerly side must be brought into contact successively with Lower and Upper Silurian, Devonian, and possibly with Vespertine near the Pulaski fault; beyond that fault, Knox beds occur again. The fault-line passes but a little way south from the Altoona mine; is crossed by the Dublin and Pearisburg pike at half a mile, possibly a little more, north from Back creek; by New river just below the mouth of Back creek; and by the Newport and Christiansburg road at only a little way south from Tom's creek: in each case bringing the red Umbral shales into contact with the lower limestones of the Knox group.

Generally speaking, the structure in the vicinity of this fault is simple, and notwithstanding the enormous vertical extent of the fracture, the

crushing and distortion are very much less than that observed near the New Garden fault in Tazewell county, the Hunter valley fault in Russell, or even the Max Meadows fault on the railroad. Where crossed by the Wythe and Tazewell pike it shows dips of thirty to forty degrees in the Lower Carboniferous, and forty to fifty-five degrees in the Knox limestones at about equal distances from the line of faulting; on the Dublin and Pearisburg road, the dip is comparatively gentle and the succession of Lower Silurian on top of Lower Carboniferous appears to be wholly conformable; a similar condition exists on New river, where the dips in the Umbral shale near the fault are only ten to fifteen degrees, while in the Vespertine further from the line the dip rises to fifty-five degrees. Here, however, the rocks on the southerly side are disturbed, and the beds are wrinkled for a mile or more. Near Tom's creek the greater disturbance is on the northerly side, where the Lower Carboniferous beds are almost vertical, though dipping toward the fault, while the Knox limestones are dipping much less sharply in the same general direction.

The structure between the Walker Mountain and Saltville faults is much less complicated than that of the next block southward. The Vespertine Coal group is exposed continuously on the northerly side of the former fault from eastern Smyth to beyond the centre of Montgomery county, and the course of the fault is so little off the strike of the beds that the thickness of the overlying Umbral shales shows very little change from Wythe county eastward. Big Walker mountain is a Medina ridge separated by a Clinton and Hamilton valley from Little Walker mountain, an Upper Devonian ridge with Lower Carboniferous sandstones and shales on its southerly slope. The dip throughout, or nearly so, is south of south-east at from ten to sixty degrees. Petty wrinkles occur in the shales, but the only material interruption of the dip on Big Walker is near the Tazewell pike, where at barely five or six miles from the Smyth county line an anticlinal evidently has its origin. This rapidly increases eastward and soon causes a considerable southward deflection in the Medina outcrop or crest of Big Walker mountain. The axis must be cut several times by Walker's creek, which flows on Knox limestone along the northerly foot of the mountain; and the fold shows no material decrease until beyond the line of Bland county; but thence to New River gap, the Medina of Walker mountain gradually approaches the Saltville fault. The interval between that fault and the Medina opposite Seddon is fully three miles, but at New River gap it is barely one mile.

The dips on the northerly side of Big Walker are comparatively gentle except for a few miles on each side of the New River gap; and it is worthy of notice in this connection that the dips throughout Big and Little Walker along the New river are much more abrupt than at any other localities. Possibly the approach of the Medina outcrop to the Saltville fault may be due as much to a thrust as to diminished strength of the Walker Creek anticlinal.

### *The Saltville Fault.*

This interesting fault, originating in Tennessee, enters Bland county just north from the Saltville and Sharon Springs road; passes at only a few rods north from that road at Sharon Springs; less than one-third of a mile north from the cross-roads at Seddon; lies north from the road for six miles beyond Seddon; thence for two miles is south, but is again crossed so that it is only a few rods north from the forks of the road at Poplar hill, in Giles county; it is crossed by New river in Buckeye mountain, very near Scott's ferry; and by the Salt Pond and Newport road in a wind-gap through Buckeye mountain at half a mile north from Newport. The dips of the southerly side are regularly south-south-eastward, and not very abrupt, rarely exceeding twenty five degrees; those on the northerly side are equally regular except near Newport, where the Trenton shales are faulted against the Knox limestone and the former are badly twisted.

The Knox limestones are shown on the southerly side of the fault, and notwithstanding the great variations of horizons on the northerly side, there is comparatively little change on the southerly side—even less than might be expected from the influence of the Walker Creek anticlinal. The variations on the northerly side possess much interest, but being due to the Clinch Mountain group of folds cannot be described until after those folds have been discussed.

### *The Clinch Mountain Group of Folds.*

Where first seen, in Scott county, Clinch and its associated Brushy mountain make up a broad monoclinal, showing a section from Medina on the crest of Clinch mountain to the highest Umbral rocks at the Saltville fault. The width of Upper Silurian and Devonian is barely three miles. In Smyth and Tazewell, however, a fold, the Burk's Garden anticlinal, arose at the foot of Clinch mountain, widening the area of Silurian and Devonian, and narrowing that of the Lower Carboniferous until at the line of Wythe county only the Vespertine remains. Similarly, gentle folds in Russell and Tazewell interrupt the dip at the north and the Medina outcrop is carried further in that direction, so that Rich mountain, whose crest is merely the continuation of Clinch mountain around a petty anticlinal, lies nearly a mile north from the previous line of Clinch. So the monoclinal of Scott county is interrupted by a great fold with a broad synclinal at the north as it enters Bland county. The structure becomes more complicated within Bland and Giles, but gives promise of returning simplicity as the group passes into Craig county beyond the limits of the writer's examination.

The Burk's Garden fold, which attains its greatest maximum in the cove of that name, quickly flattens, so that at the easterly end of the cove, the Medina outcrops of Garden mountain unite and that sandstone crosses the fold in Round mountain. The decrease is so rapid that within five miles

the Hamilton crosses the anticlinal, which at four miles further eastward seems to have disappeared.

The Pearisburg synclinal, between the Cove and Elk Garden anticlinals in central Tazewell county, lies between the Elk Garden and Burk's Garden anticlinals in eastern Tazewell, owing to the disappearance of the Cove fold. Wolf creek, rising in Burk's Garden, flows for more than fifteen miles in this synclinal within Bland county, so that Rich mountain of Tazewell, continuous with Clinch mountain further west, becomes Wolf Creek mountain of Bland county. The disappearance of the Burk's Garden fold and the rapid growth of the Kimberling anticlinal keep this trough distinct to beyond the eastern limit of Giles county. Brushy mountain, the Devonian ridge with Vespertine foothills, continues to about the eastern border of Bland, where under the increasing influence of the new anticlinals the mountain gradually disappears.

The Kimberling anticlinal was first observed on the Seddon and Mercer county road, where, though narrow, it is distinct at not far south from the summit of Brushy mountain. To the influence of this anticlinal, most probably, is due the widening of the Vespertine area further west as shown on the road crossing Brushy mountain to Hunting Camp creek. The "Wilderness" road, leading from Kimberling creek to Rocky gap, crosses the anticlinal at say a mile* from the junction of Kimberling with No-Business creek. This fold, rapidly increasing in height, causes the broad space of Devonian shales, known as the "Wilderness," which extends from Brushy mountain northward almost to the foot of Wolf Creek mountain. It soon brings up the lower rocks and the Medina in crossing it forms a long V, with the opening toward New river. The northern arm, known as Pearis mountain, reaching north-north-eastward into the Pearisburg synclinal, terminates in a peak—the Angels' Rest—near Pearisburg, where it bends on itself and becomes continuous with Wolf Creek mountain. The southerly arm is Sugar Run mountain, pointing out in the synclinal between Kimberling and a new anticlinal, the Sinking Creek, which first appears along the Saltville fault at a little way east from the Bland county line. The Kimberling anticlinal attains its maximum elevation between Walker creek and the Dublin and Pearisburg road, whence it diminishes rapidly toward the north-east. Erosion has been effective on both sides of New river, so that for several miles Lower Silurian limestones are the immediately underlying rocks.

But the comparatively rapid flattening of the Kimberling anticlinal permits the Medina to appear in the Pearisburg synclinal with double outcrop as Butte mountain at, say four miles eastward from New river. The course of the fold and its loss of elevation are shown by the deep re-entrant angle between Butte and Salt Pond mountains. The latter is the double outcrop of Medina in the synclinal between the Kimberling and

*Many of the distances given in this memoir were determined by "dead reckoning," there being no other means of making determination in the thinly settled portions. They may be either too large or too small.

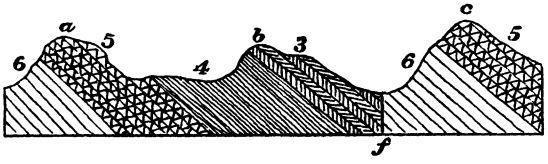



FIG. 5.—Through Sharon Springs. *a*, Garden axis; *b*, Brushy Mt.; *c*, Big Walker Mt.; *f*, Saltville fault; 3, Lower Carb.; 4, Devon.; 5, Upper Silur.; 6, Lower Silur.

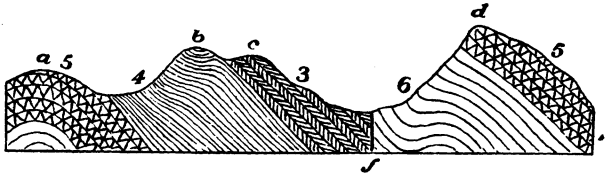



FIG. 6.—Through Seddon. *a*, Garden Mt.; *b*, Kimberling axis; *c*, Brushy Mt.; *d*, Big Walker Mt.; *f*, Saltville fault; numbers as before.

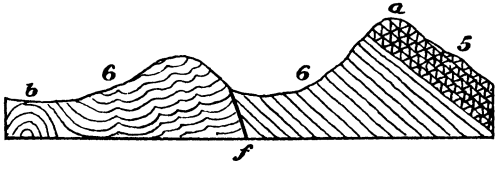



FIG. 7.—Through Newport. *a*, Big Walker Mt.; *b*, Sinking Creek axis; *f*, Saltville fault; Numbers as before.

Sinking Creek anticlinals, but it does not extend so far westward as Butte mountain, for the Sinking Creek anticlinal attains its maximum at a little way eastward from New river and Medina does not cross it until very near the easterly line of Giles county. This fold is crossed by the Salt Pond and Newport road at barely two-thirds of a mile north from Sinking creek.

For the most part the dips in the synclinals are not very abrupt; but the "Wilderness" road in crossing the Pearisburg synclinal shows Chemung with fifty degrees northerly, and almost vertical southerly dip. Northward the dip diminishes, for in Rocky gap through Wolf Creek mountain the Medina shows only twenty-six degrees. Further eastward in this trough, at the end of Butte mountain, the calcareous shales of the Trenton have been thrown into numerous and very narrow flexures. A similar condition exists in the Salt Pond synclinal on the Salt Pond and Newport road where some of the petty folds show distinct faults.

The effects produced by the Saltville fault in cutting across the southerly slope of the anticlinals are shown by the map. As the Burk's Garden anticlinal diminishes, the width of the Lower Carboniferous area increases, so that at Sharon Springs the Umbral red shales appear; but as the Kimberling anticlinal increases, the width diminishes and the whole of the Lower Carboniferous is finally lost in the fault near the Giles county line. Devonian, Upper Silurian and the upper beds of the Lower Silurian are cut off quickly at a little way further east under the added influence of the Sinking Creek anticlinal and of erosion by Walker's creek and New river, so that for several miles east and west from Poplar hill, the fault is in Knox limestone. Thence north-eastwardly to the county line, Medina is found on the northerly side of the fault, except at New River gap and for a few miles on each side of Sinking Creek gap, where erosion has cut away both Medina and Hudson.

Knox limestone is continuous on the southerly side of the Saltville fault from the Smyth county line to the end of Giles county. It is in contact with Lower Carboniferous in Bland, with Chemung, Hamilton, Clinton, Medina, Hudson, Trenton and Knox within eight miles eastward from the line of Giles county; and with Medina, Hudson or Trenton, according to extent of erosion, thence to the end of the region examined. The relations are shown in Figures 5, 6 and 7, which are merely diagrams, not actual measured sections.

*The Elk Garden Anticlinal and Wolf Creek Faults.*

The Elk Garden anticlinal of Russell and Tazewell counties gives rise to the Copper Creek fault in western Russell. The anticlinal continues in eastern Tazewell between Wolf Creek and East River mountains to within less than four miles of the Bland county line; but at some place between that and two miles west from Rocky gap in Bland county it gives rise to a double fault, the Wenonah, which was followed to within eight miles of the Craig county line. Another fault, that of Buckhorn mountain, origi-

nates nearly opposite Rocky gap or Wolf Creek gap, through Wolf Creek mountain, where it cannot be more than a few rods distant from the Wenonah. This was followed to somewhat less than twelve miles east from New river. But both faults must extend several miles further than the writer's examinations went.

The Wenonah fault, whose course is shown by the Valley ridge of Wolf Creek valley, is crossed by Wolf creek at a little way below Rocky gap, but not again except, perhaps, above the "round bottom;" it is crossed by New river at Wenonah; is touched by Big Stony creek at one mile from the river, and its peculiarities are well shown at three miles from the river on the road leading from Big to Little Stony creek. Where first seen, this fault is in Knox limestone and holds a wall of Medina and Clinton in its jaws. As one comes from the "Wilderness" through Rocky gap of Wolf Creek mountain, he finds the complete succession from Medina to Knox limestone; but within a mile below the gap he reaches the fault. There the creek breaks through the Valley ridge, in which Medina is shown with dip of eighty degrees, while on the lower, as on the upper side of the ridge, Knox limestone is shown against the Medina. The wall of Medina is wanting at Wenonah, where the fault shows Knox on both sides. The Valley ridge shows two sets of faults instead of one at three miles east from New river, where two lines of Medina are present.

The Buckhorn fault, whose course is shown by Buckhorn mountain and Little mountain, a ridge following the southerly foot of East River and Peter's mountain, is crossed by the Wolf Creek road after passing through the Valley ridge, nearly one mile below the Rocky gap. It is recrossed on the hill overlooking Mr. Carpenter's house at say two miles and a half from the gap. Thence, neither road nor creek touches the fault, though they approach it closely at the Giles county line. It brings Medina or Clinton into contact with Knox limestone.

The lines of faulting are not exposed. A reversed dip is shown on the north side of the Wenonah fault at one locality on Big Stony creek; and the Medina shows a flexure on the southerly side in the Wolf Creek gap through the Valley ridge; so that there is evidence of dragging at both localities. The dips in the intervals between these faults rarely exceed forty degrees and ordinarily are between twenty and twenty-five degrees. The interval is but a few rods wide at the gap through the Valley ridge, but beyond the New river it is nearly two miles. The faults disappear at no great distance beyond the limits of the writer's examination, for in the Rogers section, an anticlinal is shown along the foot of East River mountain in Craig county.

*The House and Barn Synclinal.*

Nothing was ascertained respecting the structure of this trough, which seems to be less and less complicated eastward. East River mountain is a monoclinal ridge with Medina as the backbone, and there must be a

synclinal between it and the similar ridge of Buckhorn mountain. The valley between these ridges is reported to show only shale.

*The Clinch Faults.*

The Clinch River system of faults continue from Tazewell county into Mercer county of West Virginia, which lies beyond the area examined for this memoir. The New Garden fault passes at a little way north from East River mountain and continues eastwardly beyond the eastern limit of Mercer county, as appears from the Rogers' section; but it is greatly diminished in eastern Mercer, for there it is in Devonian rocks, whereas in Tazewell it brings Quinnimont into contact with Knox limestone. The Stony Ridge and Abb's Valley faults certainly disappear before the eastern line of Mercer county is reached, unless their course has been greatly changed, for the writer found no trace of them in Summers county, of West Virginia, where they should be found.

The extreme vertical extent of the several faults is approximately as follows:

| | |
|---|---|
| Draper mountain | 12,500 feet. |
| Max Meadows | 9,800 " |
| Pulaski | 9,600 " |
| Price mountain | 10,000 " |
| Walker mountain | 10,000 " |
| Saltville | 10,000 " |
| Wolf creek | 2,000 " |

## II. THE GROUPS, WITH COMPARATIVE NOTES.

The section is a long one, reaching from the Umbral of the Lower Carboniferous to the lower beds of the Potsdam. No detailed measurements were attempted and in most cases no effort was made to estimate thicknesses. Only the more general features are summarized here, as most of the details given in previous memoirs are equally applicable to this area.

*The Carboniferous.*

The Coal Measures are not reached but the Lower Carboniferous is represented by the Umbral and the Vespertine. These groups are shown in Bland county along the southerly slope of Brushy mountain; in Wythe, Pulaski and Montgomery counties, they form the foothill of Little Walker mountain; they are present in Wythe and Pulaski counties in the area between the Max Meadows and Pulaski faults; and in Montgomery, on Price mountain.

*The Umbral.*—Prof. Fontaine makes the thickness of the upper portion, the Umbral red shales and shaly sandstones, to be 1090 feet in Brush and Price mountains of Montgomery county, and the writer finds 996 feet in the New River gap through Brush or Little Walker mountain. In the Memoir on Lee county, &c., the writer regarded these Montgomery county shales as Vespertine, but he now feels that that identification is

erroneous and that the shales belong to the Umbral or Greenbrier series. These shales are well shown on the various roads crossing Brushy mountain in Bland and especially well along the various roads crossing Little Walker, in Pulaski and Montgomery counties. They occasionally contain a thin bed of coal, which was seen on Brushy mountain, in Bland, and on the Norfolk and Western railway near Clark's summit, in Pulaski county; but the bed is of no importance. The rocks are reddish shales, mostly sandy, occasionally compacted into earthy sandstones; but in nearly all cases the bedding is irregular. So far as observed, these beds are not fossiliferous.

A silicious limestone, too impure to be used in making lime, occurs under these shales. It is said to be seven or eight feet thick on Stony Fork of Reed creek, in Wythe county: it is rather less on the railroad in Clark's summit cut four miles and a half east from Max Meadows; and is a little thicker on Brushy mountain, in Bland county. In many ways this is exceedingly suggestive of the silicious limestone which occurs at the summit of the Vespertine in Pennsylvania and it may be the representative of that rock. This limestone the writer takes to be in all probability the separating bed between the Umbral and the underlying Vespertine, but with greater affinity with the latter. Unfortunately, the only locality where measurements can be made without great expenditure of time is along New river, but there the limestone was not recognized and an arbitrary line had to be assumed for separation of the two groups.

The variations in the Umbral within South-western Virginia are not without interest. The section obtained in Lee county showed

1. Shales and sandstone with thin limestone.....705′
2. Limestone and calcareous shales .....150′
3. Cherty limestone..... .....200′

In Brushy mountain of Washington county on north side of the Saltville fault, the upper division retains its thickness while the lower divisions increase vastly, the measurements being,

No. 1..... 800 feet.
No. 2.....1470 "
No. 3..... 605 "

But in western Smyth county, where the group is crossed by the road leading to Saltville through Brushy mountain, there is manifestly a serious decrease in thickness of the limestones, while the shales appear to have decreased very slightly. Within Bland county, in the same mountain, the red shales are found thick, but the limestone has disappeared. This is simply the condition which one should expect to find here, when it is remembered that on the north-westerly side of the Great Valley in Pennsylvania and Maryland, limestone is found almost wholly absent from the isolated patches of Umbral: similarly, with the disappearance of the calcareous matter, the fossils disappear. Prof. Fontaine came to the same conclusion with respect to the relations of these shales after com-

paring them with the section obtained near Lewisburg, in Greenbrier county, of West Virginia.

*The Vespertine.*—This great period is represented by sandstones and shales with coal beds, having in all an extreme thickness of not far from seven hundred feet. The bottom of the group is taken to be a grayish sandstone, sometimes slightly conglomerate, often with impressions of *Spirophyton*, and about thirty feet thick. It is a characteristic rock resting directly on sandy beds which mark the transition to Chemung and in which the dividing line cannot be drawn very closely. On this sandstone rests the succession of shales and sandstones, the latter varying from gray to blue or red, from compact to shaly, from good building stone to miserable rubbish. The general succession is fairly well shown in many of the smaller gaps through Brushy mountain of Smyth and Bland, as well as in the similar gaps through Little Walker in Wythe, Pulaski and Montgomery; a more accessible section is along the Norfolk and Western railroad for seven or eight miles west from Pulaski.

The change in this group is as marked as that in the Umbral. The section in Lee county shows

Reddish silicious beds, some shale.....150 feet.

Some part of which must represent the Vespertine. No coal was seen here. In the North Holston section near Mendota, in Washington county, the Vespertine can only be in the concealed space of eighty feet at the bottom. But the sandy beds increase toward the north-east so that before the line of Smyth county has been reached a coal has been mined in the river bed, while the shales and sandstones form a notable foothill to Brushy mountain. At the Laurel gap, in Smyth county, the estimated thickness is about 500 feet, while in the same ridge within Bland county, the thickness appears to be approximately the same. But followed northwestward into Tazewell county, this division is found insignificant where shown among the Clinch faults, being thinner on Indian creek than in Pennington's gap, in Lee county. Along the foot of Brushy and Little Walker mountains, one finds the Vespertine very much as in South-central Pennsylvania, a mass of shales, sandstones and irregular coal beds, capped by a silicious limestone.

The feature of especial interest is the great development of Vespertine coal beds within Wythe, Pulaski and Montgomery counties. These have been worked, especially in Montgomery county, for many years, and a summary account of them was given by Prof. W. B. Rogers, in his report for 1838. Prof. J. P. Lesley gave an excellent statement respecting the beds and workings as they existed in 1860; while Prof. Fontaine has described in detail the beds of Brush and Price mountains, in Montgomery county.

According to Capt. Boyd, thirteen beds or streaks of coal occur in a vertical space of less than 400 feet within the gap made through Little Walker mountain by Stony Fork of Reed creek. The first five of these beds are embraced within a column of 100 to 120 feet, No. 1 resting on the

sandstone, known as "Quarry rock," which the writer has assumed as the base of the Vespertine. The first three beds alone possess any economic interest, as no others are mined anywhere within this region.

The lowest bed is usually very thin, but on Cloyd's mountain in Pulaski, and on Brush mountain in Montgomery, it becomes of workable thickness, two and a half to three feet. The second bed has been opened near the Wythe and Tazewell pike in Wythe county; at the Altoona mine in Pulaski; at several places along Tom's creek in Montgomery, all in the foothill of Little Walker or Cloyd's or Brush mountain, as the ridge is termed in different portions of its extent. Apparently the same bed has been mined near Sharon Springs, in Bland county; and on Price's mountain, in Montgomery. It varies from nearly four feet of nearly solid coal in Wythe to twenty-two feet of shale and coal in Pulaski, and nine or ten feet of coal and shale in Montgomery. But these are extreme measurements and the bed exhibits great and sudden variations in thickness, owing to the immense pressure which the yielding material has suffered. A similar condition exists in Bland county; but the variations in Price's mountain are comparatively small. The third bed was mined systematically only at the Altoona mine in Pulaski, though it was opened in Wythe county, near the Wythe and Tazewell pike. Its thickness at these localities is said to be between three and four feet. It is not worked now.

The physical structure of the coal shows great variations, which cannot be accounted for always by supposing different degrees of pressure. The coal from the second bed appears everywhere to have undergone much greater change than either the first or the third. In Wythe county at the Boyd mine, in Pulaski; at the Altoona mine and on the Dublin and Pearisburg road; and in Montgomery county, on Tom's creek; as well as in Bland county, near Sharon Springs, the coal from the second bed appears to have been crushed into fragments, which were pressed and rubbed until they were reduced to laminæ, so loosely packed in many places as to be easily separable by the fingers. But the coal of the first or third bed may be found on the same hillside, hard enough to bear transportation, though it shows with sufficient distinctness that it too has been subjected to severe crushing and rubbing. It has been broken into fragments, which have been rubbed together until thoroughly glazed. But the rubbing did not reduce the fragments to laminæ.

This variation may be due to difference in chemical composition or to the fact that the thinner beds are not broken by shale partings. It is of interest, however, to note that notwithstanding all this crushing and rubbing, the penetration of coal layers by shale layers in the second bed is no greater than that often seen in coal beds within the very little disturbed Coal Measures area of South-western Pennsylvania and the adjacent parts of West Virginia. The crush of strata in Price's mountain has been comparatively slight, despite the faulting, though there also, it is sufficiently clear that the greater part of the crushing was endured by the coal, as being the more yielding substance.

Analyses of coals from several of the pits have been made by Mr. A. S. McCreath, the accomplished chemist of the Second Geological Survey of Pennsylvania. The results taken from his memoir on the Resources of Virginia, are as follows:

1. Guggenheim bank, Brush mountain, near head of Tom's creek.
2. Smith bank, also on Brush mountain, one mile further east.
3. Blacksburg M. & M. Co., also on Brush mountain.
4. William Perfator, also on Brush mountain.
5. William Meyers, Price mountain.

All of these are from Montgomery county:

6. Altoona mines, Pulaski county.
7. Stony Fork, of Reed creek, Wythe county, 2d bed.
8. Same locality, 4th bed.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Water | 1.228 | 0.816 | 0.615 | 0.725 | 1.080 | 0.236 | 0.466 | 0.620 |
| Volatile matter | 11.652 | 11.324 | 12.870 | 12.215 | 9.675 | 9.459 | 16.264 | 17.853 |
| Fixed carbon | 73.012 | 75.618 | 70.924 | 72.737 | 74.013 | 49.353 | 55.615 | 59.427 |
| Sulphur | 0.548 | 0.697 | 0.481 | 0.333 | 0.682 | 1.122 | 0.995 | 1.575 |
| Ash | 13.560 | 11.545 | 15.110 | 13.990 | 14.550 | 39.830 | 26.660 | 20.525 |

The coal from several of the mines is in good repute. Much of that from Tyler's mine near New river is used as grate fuel in villages along the railroad west from New river. The Tom's Creek mines are worked and the coal is carried in wagons nine or ten miles to Bang station, on the railroad, whence, with the Price Mountain coal, it is distributed to villages in the vicinity. In spite of the great percentage of ash and the much higher cost per ton, the Tyler and Price Mountain coals are preferred to Pocahontas coal for grates, as they are practically free-burning, having very slight tendency to coke. The Altoona coal is used at the salt-works in Smyth county, and at the Bertha zinc-works in Pulaski.

A comparison of the fuel ratios is interesting. Arranged in order from north-east to south-west along the foot of Little Walker mountain we have

| | | |
|---|---|---|
| No. 2 | 15 | 85 |
| No. 1 | 16 | 84 |
| No. 3 | 18 | 82 |
| No. 4 | 16 | 84 |
| No. 6 | 19 | 81 |
| No. 7 | 29 | 71 |
| No. 8 | 30 | 70 |

An analysis of the Tom's Creek coal is given in Prof. Rogers' report for 1836, p. 17, which shows the ratio of

| | |
|---|---|
| Volatile | 16 |
| Fixed | 84 |

or the same as No. 2, of Mr. McCreath's analyses of Tom's Creek coals. These analyses show that the proportion of the volatile combustible matter decreases north-eastward, so that one is prepared to find not a semi-bituminous coal such as these, but a true anthracite in Narrowback mountain at the Dora mines further north-north-east, near Harrisonburg.

The material for comparison of the areas lying further south-east, in the Valley, does not exist. No analyses of coals in the area between Max Meadows and Pulaski have been made, so far as the writer knows; only one analysis of the Price Mountain coals by McCreath, and one of the Catawba coal in Botetourt county by Rogers, have fallen under the writer's notice; these show:

| | | |
|---|---|---|
| Price mountain ..... | 13 | 87 |
| Catawba..... | 21 | 79 |

a very notable difference. Whether or not the specimens were taken from different parts of the same bed or from different beds cannot be ascertained.

The Vespertine coal beds attain their chief importance within the counties of Wythe, Pulaski, Montgomery, Roanoke and Botetourt, a distance along Little Walker mountain of barely 105 miles. But isolated patches of slight extent preserved in synclinals within Augusta and Rockingham counties, show that the field with beds of workable thickness extended to certainly 100 miles further north-north-east, thus giving a length directly measured of nearly 200 miles. Exposures in Wythe, Pulaski and Roanoke show that the Vespertine beds reached far into the area now known as the "Great Valley," fragmentary patches still remaining at a distance of barely twelve miles from the Archæan, while exposures in Bland and Rockingham show that the productive coal area in Virginia extended to some distance beyond the line of the Saltville fault. Certainly it was 200 miles long by fifteen miles in Virginia; and the width may have been twelve miles greater toward the south-east, reaching to the Archæan. The whole area may be estimated at beyond 5000 square miles, of which only insignificant strips and patches have escaped erosion, amounting in all to not more than 130 square miles. How much further north-eastward this area extended cannot be determined, for in Pennsylvania and Maryland the numerous folds with the disappearance of the faults have thrown the most easterly outcrop of Vespertine, to a distance from the Archæan greater than that of the Abb's Valley fault from the Archæan in Virginia. No workable coal beds occur in Pennsylvania and Maryland within the Vespertine, but what existed in that portion of the Vespertine which has been removed by erosion, we may conjecture from the conditions occurring in Virginia within the same space.

Within Virginia the coal beds diminish quickly in importance in all directions from the area already defined. South-westward, the coal-bearing division of the Vespertine diminishes and the last trace of it occurs on the North fork of Holston, near Mendota, in Washington county, where coal is said to be found in the river-bottom at low water. North-westward

the coals diminish. In Lee, Wise, Russell and Tazewell counties, of Virginia, this lower division is either insignificant or wanting—but further north-west, in Greenbrier county, of West Virginia, Prof. Fontaine* found the sandstone division with strings and beds of coal, which, however, are interesting more because of their existence than because of any economical importance. The total thickness of the whole series there is about 290 feet.

No Vespertine is found in or immediately adjoining the Great valley, beyond Augusta county, of Virginia; but the petty areas preserved on the crests of synclinal ridges are among what Prof. W. B. Rogers termed the Allegheny mountains, in Hardy, Hampshire and Morgan counties, of West Virginia. There the coals are usually very thin, as they are also under the great anticlinals of Randolph and Tucker counties, of West Virginia, Allegheny county, of Maryland, Bedford, Huntingdon, and the counties further north in Pennsylvania. The coal is present in all of these, but not in such shape as to deserve more than passing notice; the thickness seldom exceeds a few inches and the large percentage of ash leads most persons to regard the coal as anthracite. Along the lines mentioned, the sandstones show a decided thickening, becoming 1100 feet or more in Bedford county, of Pennsylvania; but the thinning is very marked in a north-westward direction, as the whole thickness in Fayette county, of Pennsylvania, is barely 400 feet. There, the last westward exposure on the easterly side of the Appalachian region, it appears to contain no coal.

*The Devonian.*

The Devonian is represented by Chemung and Hamilton only, the Catskill and Carboniferous being absent. In Bland and Giles counties Devonian rocks occur in the "Wilderness" area of Kimberling creek, and they make up the great part of Brushy mountain, in the former county; they underlie the "Poor valley" of Walker mountain, and make the mass of Little Walker and Max Meadows mountains, while a narrow strip lies along the north side of the Draper Mountain fault in Pulaski county. Except in the "Wilderness," where the Oriskany was recognized, no line could be drawn between Devonian and Upper Silurian, the shales of the one passing interceptibly into the shale of the other.

*Chemung.*—The Chemung, as seen on the North Holston near Mendota, is 350 feet thick, but it is wholly absent from Stony mountain in Lee county. Eastward, or rather north-eastward in Brushy mountain, the thickness increases rapidly, so that north from Saltville, in Smyth county, it is certainly twice as great as at Mendota. On the same mountain, in Bland county, the increased thickness is noticeable even to the most careless observer, and on the road leading from Walker creek to Hunting Camp creek, the following succession was seen:

1. Sandstones with some shales.
2. Conglomerate sandstone.

*Loc. cit., pp. 44 and 45.

3. Shales and sandstone.
4. Conglomerate sandstone.
5. Shales and flags.

No effort was made to secure measurements here, as the road is tortuous and in unbroken forest, but an excellent section can be obtained by instrumental measurement, as the stream bed affords almost continuous exposures below the upper conglomerate. The flaggy sandstones between the conglomerates are bluish red and resemble closely the rocks immediately overlying the upper conglomerate; but details respecting the great part of No. 1, which includes beds of passage from Vespertine to Chemung, are practically wanting here. In the Laurel Fork gap through Brushy mountain in Smyth county, and in the Seddon gap in Bland county, these are shown to be gray to blue sandstones.

The section is similar in the Little Walker mountain gaps. On New river the distance from the "Quarry rock" to the conglomerate is not far from 900 feet, but no exposures occur in the interval along the railroad. Almost continuous exposures on the Newport and Christiansburg road show the space to be filled with gray to yellowish flags and sandstones with few shales.

At all localities the beds of No. 3 consist of more or less argillaceous concretionary sandstones passing downward into shales with bluish red or deep red flaggy sandstone. The flags, though forming a small part of the mass, are sufficiently hard to support the cliffs of this division, which are seen in many ravines. These beds are well exposed on all graded roads crossing Brushy and Little Walker mountains; along the ravine followed by the road to Hunting Camp creek, in Bland, they are shown in cliffs. There, however, the flags appear to be more abundant than at any other locality. No satisfactory estimate was made of the thickness, but as exposed along the Hunting Camp road, in Bland, it is not less than 1000 feet.

No. 5 consists of flags and shales, olive, gray, blue and drab, which are well shown at many localities.

The conglomerates are rarely shown in place. No. 2, which is not far from forty feet thick on Brushy mountain and is certainly much thicker in Little Walker, was seen in place only on the road to Hunting Camp creek, on New river and on the Newport and Christiansburg road over Little Walker, yet this conglomerate is the "backbone" of both mountains, and to its ragged outcrop is due the irregular crest of each. Its fragments are always abundant and ordinarily they are characteristic. The pebbles vary in size from a pea to a hen's egg; while in several of the layers they are flat and, curiously enough, in some parts their longer axis is almost vertical to the plane of bedding. Almost without exception these are of quartz or quartzite. The lower conglomerate was seen in place only on the Hunting Camp Creek road in Bland county, just where the road leaves the long gorge and emerges upon the "clearing." In general features it closely resembles the upper conglomerate.

In the New River section fragments with Chemung fossils are plentiful to a vertical distance of not far from 500 feet above the conglomerate, but beyond that the fossiliferous fragments become rare and soon are altogether wanting. A fossiliferous sandstone containing *Chonetes* and *Pthonia*, both Chemung forms, together with many other forms not easily recognizable on the weathered surface, was seen on the Dublin and Pearisburg pike at between 300 and 400 feet vertical distance above the supposed place of the upper conglomerate. The transition thence to the Vespertine, as shown in the excellent and almost continuous exposures along that road, is absolutely imperceptible—there is no change to the "Quarry rock," and the drawing of the line of separation at the bottom of that rock is wholly arbitrary here. But at many other localities a change occurs at about 200 feet below that rock, bringing in some bluish sandstones. Chemung forms become very abundant immediately below the upper conglomerate. Good collections can be made on Brushy mountain in Bland county along the Seddon and Mercer road, as well as along the road from Point Pleasant to Kimberling creek. Excellent localities on Little Walker are on New river and on any of the roads crossing the mountain in Pulaski and Wythe counties. No doubt good collections can be made within a mile and a half of Pulaski on the road leading over Draper mountain.

The geologist familiar with the Chemung of Pennsylvania and Maryland will recognize a familiar section here: the two conglomerates with variegated shales below them passing into the flags, while between them are the flags and shales passing through clayey concretionary sandstones to the upper conglomerate. The similarity fails above that conglomerate in that the red shales are wanting, and the passage to the Vespertine is through sandstone rather than through shale. The condition is more nearly that of South-western Pennsylvania where, as here, the Catskill is absent and the Chemung is carried directly to the Vespertine. The thickness of the section in Bland county appears to be very nearly the same with that of the section in northern Bedford county of Pennsylvania, nearly 300 miles away along the line of strike. This persistence through so great a distance makes more remarkable the entire disappearance of the group between Bland Court-house (Seddon) and Pennington's gap in Lee county, only 125 miles away at the south-west.

This group evidently reached to the south-easterly side of the "Great valley," for the beds upturned alongside of the Draper Mountain fault are within twelve miles of the Archæan.

*Hamilton.*—The line between Hamilton and Chemung cannot be drawn satisfactorily during a reconnaissance, as the passage from one to the other is by no means abrupt. So gradual, indeed, is the passage here, as well as in a great part of the Appalachian region, that the older geologists of both Virginia and Pennsylvania placed the series together as a single group, their No. VIII. The Hamilton shales are gray to black, and evidently represent only the lower part of the group as found further northward. They are shown in the "Poor valleys" of Walker and Cove mountains,

as well as in Bland county around the foot of Round mountain. They contain little of interest.

*The Upper Silurian.*

No definite line of separation between Upper Silurian and Devonian could be made out except in the "Wilderness" area of Bland and Giles counties; there the Oriskany is present, which makes the boundary distinct. Upper Silurian, represented by Oriskany, Clinton and Medina, makes up the most prominent features of the district, Medina being, *par excellence*, the mountain-making rock.

The *Oriskany* was seen only in Bland county, where it is exposed at the foot of Round mountain and the Garden mountains, as well as along the foot of Wolf Creek mountain in the "Wilderness." The rock is a thin sandstone, which resists the weather so well as to make a small ridge. If this rock be present in the "Poor valley" between Big and Little Walker mountains, it must be very thin and must yield readily to the weather, as that valley was crossed on four lines, each affording good exposures, but without Oriskany. As shown in the "Wilderness" the rock is a moderately coarse gray sandstone, evidently not more than ten feet thick, and containing, in addition to the ordinary forms, impressions of large crinoidal joints.

The *Lower Helderberg* may be present in the "Wilderness," but no positive proof exists. Fragments of white chert containing a delicate *Stromatopora*, and seen near Round mountain, have much resemblance to the chert bed at the base of the Oriskany or top of the Lower Helderberg. Aside from those fragments nothing referable to the Lower Helderberg was seen in any of the "Poor valleys."

The *Clinton* forms a bench around Round mountain; on the Garden mountains; on Wolf Creek mountain and its continuation in Pearis and Sugar Run mountains; on Big Walker and Cove mountains. Everywhere it presents the same features, variegated shales with white sandstones near the ores. The "fossil" ore occurs, but little only is known respecting either its quantity or quality. It appears to be abundant, though silicious, on Wolf Creek mountain, if one may judge from the fragments where the ore horizon is crossed by the road near Wolf creek or Rocky gap.

The *Medina* is well known as the mountain-making rock. Its outcrop forms the crest of Cove, Big Walker, Garden, Round and Wolf Creek mountains; it makes a double outcrop on Pearis and Sugar Run mountains, as well as on Butte and Salt Pond mountains; while it is shown on each side of the House and Barn synclinal in Buckhorn and East River mountains.

The *Upper* or *White Medina* is very far from being coarse, though a few layers of conglomerate were observed in it. The best exposure is in the gap made by New river through Big Walker mountain, where the estimated thickness is 375 feet. For the most part the rock is white, and on long exposure the surface becomes beautifully polished. This is char-

acteristic of the rock along an outcrop of fully 400 miles. Some brown or reddish-brown layers occur in this division, but their thickness was not ascertained. Aside from *Arthrophycus harlani* and a *Scolithus*-like form, no fossils occur in the sandstone.

The *Lower Medina*, composed of reddish sandstones and shales, is the imperfect terrace on the northerly side of the mountains, and, as was stated in a previous memoir, this is clearly the same with the Terrace group of South-central Pennsylvania, which has been identified by Lesley, and therefore by the writer in his Pennsylvania report, as the Red Medina of New York. The thickness cannot be given with any degree of certainty, as the rock passes downward without break into the Hudson ; ordinarily it is much disturbed. The best exposure in detail is on the Tazewell and Wythe pike as that road descends the northerly side of Big Walker mountain toward Sharon Springs. There, within 100 feet vertically below the White Medina, is a fossiliferous bed, six to eight feet thick, containing *Rhynchonella, Orthis, Modiolopsis, Avicula emacerata, Ambonychia radiata* and fragments of *Orthoceras*, which were collected during an examination lasting but a few minutes.

The relation to the Lower Silurian, therefore, is intimate, so intimate that the writer is more than ever convinced that there is room for doubting the accuracy of any identification which makes the Terrace group of Southern Pennsylvania the equivalent of Medina in New York.

### *The Lower Silurian.*

The Lower Silurian is represented by Hudson, Trenton and Knox limestone. Hudson beds occur only on the steeper slopes of the Medina mountains ; Trenton is at the foot of such mountains, but within the counties described in this memoir, is rarely seen in the broader limestone valleys. The Knox limestone is the surface group in the "Rich valley" of Bland and Giles ; on both sides of New river in Giles county ; and is the great limestone group cropping out over so much of the "Great valley" in Wythe, Pulaski and Montgomery counties.

The Hudson consists of red to yellow sandy shales, which pass with equal indefiniteness into the Red Medina (?) above and into the calcareous shales of the Trenton below. The Trenton beds are calcareous shales with streaks of impure limestone passing downwards into pure massive limestones, some of which would be valuable as marbles. The lower beds become more or less silicious and show embedded nodules of chert.

These cherty beds afford transition to the Knox limestones, which are very cherty in the upper portions. The lower portions contain much shale with silicious limestones, and near the base is a curious limestone, somewhat silicious, which is veined with white spar and contains great blotches of the same material. This is a notable bed, which is recognized in many places where it promptly affords a key to the puzzles. Its presence on New river and at several other localities in Pulaski county shows the relations of the rocks on both sides of the Walker and Pulaski faults, and

proves the presence of Knox beds in that part of Pulaski county lying between the Altoona railroad and New river. A good section of this group should be obtained along the Valley pike in Wythe county beyond Reed creek, beginning near Kent's Mills, where the series is well exposed almost to the fault of Draper mountain.

Along the southern side of Wythe and Pulaski counties, the Knox beds, more or less dolomitic, carry important deposits of zinc and lead ores, some of which have been utilized. The mine of the Wythe Lead and Zinc Company will be described in its own place. There the lead ore has been worked for more than a century, but the zinc ore had been neglected until the near approach of the Cripple Creek extension of the Norfolk and Western railroad led to its development and preservation. The zinc ores at the Bertha mine, also in Wythe county, yield a spelter of the finest quality. This strip of zinc and lead ores extends from Smyth county across Wythe and Pulaski, but developments thus far have been confined to Wythe county.

The brown hematites of the Knox limestones in Pulaski and Wythe counties, along the New river and its tributary, Cripple creek, have been well described by Mr. A. S. McCreath,* who examined most of the openings and analyzed the ores, using samples collected by himself. The ore lies not far from the lead and zinc, and appears to be present in great quantity. Much of it is of excellent quality.

Manganese oxide and barytes are reported as occurring at several localities, but no information was received respecting the quantity.

*The Cambrian.*

Here are placed the Lower Knox shales and the Potsdam. The former are probably equivalent to the Hydromica schists of Pennsylvania and the lower part of the Calciferous of New York; the latter is the Potsdam of New York, vastly increased in thickness.

The Knox shales are shown in Draper valley, within Wythe and Pulaski; they surround Lick mountain in Wythe and continue for some distance eastward along the anticlinal; they are continuously exposed within a mile of the southern border of Wythe and Pulaski counties, and are brought up for a little way under an anticlinal lying south from the Wytheville synclinal.

For the most part these shales are reddish, sometimes streaked with white, usually more or less greasy, often talcose-looking on the slipped surfaces. The rock is hard and is used for repairs of the Valley pike. An admirable exposure occurs on that pike for some distance east from the Cripple Creek railroad crossing, and one almost equally good is on the road crossing Lick mountain on the way from Wytheville to Brown Hill furnace. Streaks of limestone occur in the upper part, but they are wanting below. In the upper part are also some beds of yellow and blue shales,

* The Mineral Wealth of Virginia tributary to the lines of the Norfolk and Western and Shenandoah Valley Railroad Companies. 1884.

but they are thin. These shales are hard enough to form bluffs; where they have been long exposed to the weather, their surface becomes very dark and the dismal effect is increased by the abundant growth of ashen lichens, which are never absent from the older outcrops. The thickness of the group cannot be determined without careful study, as at all localities crossed the beds are badly folded; but it cannot be less than six hundred feet.

The Potsdam forms the great mass of Lick mountain; is the sandstone of Draper mountain; and is found along the southern border of Wythe, Pulaski and Montgomery counties. The upper beds are alternations of sandstones and shales. The sandstones are mostly white, vary from slightly conglomerate to exceedingly fine grain, almost like quartzite; many layers are hard and on long exposure become beautifully polished. The lower beds shown in the deeply eroded gorges of Lick mountain and on the northerly side of Draper mountain, are sandy shales, mostly grayish and often so thickly bedded as to be shaly sandstones. The bottom of the group is found not far from the line of Grayson and Carroll counties, but that line was not reached by the writer. No measurement to determine the thickness of the group was attempted, as the bottom is not exposed in either Draper or Lick mountain, but in Draper the thickness is not less than 2000 feet, the calculation being based on the dip and a rough estimate of the horizontal distance through the mountain from the fault to the bottom of the Knox shales. The amount of rock exposed along the road traveled over Lick mountain is not so great, but the deeper ravines of that mountain should show an equally extensive section.

No fossils were observed in the Knox or Potsdam shales, but the search for them was not diligent. Some layers of sandstone near the bottom of the Potsdam sandstone yield *Scolithus linearis* abundantly on Lick mountain; but neither that nor any other fossil was seen in the Potsdam of Draper mountain.

Ores of manganese and iron are reported as occurring near the bottom of the Knox shales, but no effort has been made to develop these except in a small way on Lick mountain.

## III. THE REGION NORTH FROM BIG WALKER'S MOUNTAIN, BLAND AND GILES COUNTIES.

In descending Walker's mountain by the Wythe and Tazewell pike, one leaves the Medina at the summit and comes to a fossiliferous bed at barely one hundred feet vertically below the mountain crest. This is from six to eight feet thick and contains many typical Hudson fossils in great numbers; *Rhynchonella increbescens*, *Orthis occidentalis* (?), *Avicula emacerata*, *Ambonychia radiata*, *Modiolopsis* with fragments of *Orthoceras* were collected within a few moments. Other fossiliferous beds were seen lower down the slope, but no specimens were taken. These reddish shales with streaks of sandstone pass gradually into the yellowish shales of the Hudson, which in turn pass into the dull reddish calcareous shales or shaly

limestones of the Trenton. The cherts at the base of the Trenton or top of the Calciferous are reached at the first house. Thence exposures are rare until at the Sharon Springs some sandstones with indefinite dip are shown in the stream. These springs, which are the sources of the North Fork of Holston river, are very large and issue from very near the Saltville fault. The place was a popular summer resort in former times, but the construction of the railroad through the Great valley made it practically inaccessible and the hotel has few visitors.

The Saltville fault passes very near the yard at Sharon Springs, the ridge behind the hotel being sandy. The dip where the pike passes through this ridge is southward at fifty-eight degrees, and the silicious limestone of the Vespertine is shown at the northerly foot of the hill. The lower beds of the Vespertine have been eroded near the pike, but at a fourth of a mile eastward they form a low hill, in which a coal bed was mined at one time to supply local needs. The pits have fallen shut and most of them appear to have been little more than extensive strippings along the outcrop. The thickness varies greatly; it is reported as eleven feet at one place. The coal is badly twisted, but the crushing and polishing are much less than at many other localities. Notwithstanding this crushing, the volatile matter is considerable and the coal cokes on the fire. The rocks enclosing the coal are regular and not much distorted except at one place, where the distortion may be due to a surface creep.

The Tazewell pike continues northward, crossing Garden mountain, and, within a direct distance of four miles, entering Burk's garden, to which reference was made in the notes on Russell and Tazewell counties. This road was not followed beyond the abandoned coal-pits.

The Rich Valley road is near the top of the Calciferous until six or seven miles beyond Seddon, where it crosses the Saltville fault; but within a little way it returns to the Calciferous and remains in it. The Calciferous limestones and shales are apparently non-fossiliferous; certainly fossils are rare, none having been seen, though the exposures were examined for several miles. The dips vary from twenty to forty degrees, the more common rate being not far from thirty. Waddell's lead mine, abandoned long ago, is a group of rude excavations in Calciferous at five or six miles east from Sharon Springs. The road leading to Hunting Camp creek leaves Rich valley at nearly seven miles from the springs. The dips quickly steepen on that road, so that limestones exposed in the little stream-bottom near the first house are dipping southward at from fifty to sixty degrees. The Saltville fault is reached at barely half a mile, at top of an abrupt grade beyond the first house.

The blossom of a thin coal bed, indicating a thickness of not more than ten inches, was seen at the top of the first hill, which may be the same with a thin bed digged in the bed of a run not far west from the road. The silicious limestone is exposed at R. Waddell's house and a coal bed is worked in a small way by Mr. Harmon, very near the summit of the road, which is far from being the summit of Brushy mountain. The pit

was not examined and the thickness of the bed, which is said to be between three and four feet, was not ascertained.

The road descends rapidly on the northern side to a large branch of Hunting Camp creek, which follows a long gorge through Brushy mountain. The *upper conglomerate* of the Chemung is shown soon after the stream has been reached and forms a ridge on each side of the road; the exposed thickness is not far from forty feet. The layers of conglomerate are distinct and one of them is ferruginous, with pebbles as large as a walnut. The gorge below this is exceedingly rugged, the shaly beds of the Chemung being held in cliffs by thick flags which are shown nicely in the stream so often crossed by the road. A second gray sandstone, with layers of conglomerate and closely resembling the former, is shown just above the mouth of the gorge. The more shaly beds at the base of the Chemung are shown as one approaches Hunting Camp creek, at Mr. Soutter's. There one sees, in looking back, that the tributary streams have cut Brushy mountain into parallel ridges, each with one of the harder Chemung sandstones for its crest.

The lower shales of the Chemung with their hard flags form a low but very distinct ridge, which follows the foot of Brushy mountain and curves round the easterly end of the Garden anticlinal to form a similar ridge for a little distance between Round and Rich or Wolf Creek mountains. The Hamilton shales, which can be hardly separated from the Chemung during a hasty examination, continue to the northerly side of Hunting Camp, where the road first reaches it, though at a little way further down the stream cuts almost to their base. The Oriskany sandstone is exposed just north from the creek at barely a mile below Mr. Soutter's and thence its fragments are very numerous. The rock crosses the end of Round mountain as the Burk's Garden anticlinal dies away, and it is shown in the road at a short distance above the mouth of Hunting Camp creek. The most notable fossil is the stem of a *crinoid* of which individual joints are extremely common. *Spirifera arrecta* appears to be more abundant than any other of the ordinary forms. Evidently associated with the sandstone, but not seen in place, is a white chert, which contains a delicate *Stromatopora*. Whether this represents the Lower Helderberg or not could not be determined.

The road to Seddon leaves Hunting Camp creek at about two miles from its mouth and crosses Brushy mountain to Rich valley, at Seddon. The shales northward from the creek on this road are without doubt largely Hamilton, but beyond the creek southward the road quickly enters the low ridge of olive shales and flags, which has been referred to already as persistent along the foot of Brushy mountain for fully twelve miles. As the road ascends the mountain, it passes over olive flags with olive, gray, ashen, blue and yellow shales, continuing to the summit of the road; the southward dip being somewhat irregular, but rarely falling below twenty, or rising above forty degrees. These shales show no fossils aside from occasional impressions of crinoid joints and rude traces

of fucoids on the surfaces of the flags. Similar shales and flags continue for a little distance down the southerly side of the mountain, but the upper beds are soon reached and some of them are very fossiliferous. On one slab *Rhynchonella orbicularis*, (?) *Grammysia subarcuata*, *Modiomorpha*, *Mytilarca* and *Edmondia* were seen and the specimens were remarkably well preserved. The gray sandstones of the group are not exposed along the road, but their fragments are very abundant and the rocks themselves form the summits of the subordinate ridges. The Kimberling anticlinal is crossed at less than half way down the mountain and brings up again at least one of the sandstones. The passage to Vespertine is not easily made out. A mass of red sandstone occurs in a narrow gorge, say half a mile from Seddon, which probably marks the bottom of the Vespertine. Coal belonging to that group has been mined in a small way at half a mile west from Seddon and at about the same distance north-east from that village. A mine has been opened for domestic use at about three miles further east; but none of these pits was visited. The topography is reversed on the road crossing Brushy mountain, the long gorge being on the southerly side.

The road in Rich valley lies in Calciferous for somewhat more than six miles from Seddon or to a little beyond Point Pleasant. The chert ridge is south from the road and attains to considerable height in its eastern extension. The road lies south from the Saltville fault to Point Pleasant, but almost directly beyond that place it turns northward and thence to the road crossing the mountain to Kimberling creek it lies north from the fault. The dips in the limestone seldom exceed thirty degrees, except near the fault, where they become fifty-five and sometimes even more. Exposures are very indefinite along the road to Kimberling creek, as it ascends the slope of Brushy mountain. No coal blossom was seen and no coal is digged anywhere near the road. Fragments of the Chemung *upper conglomerate* are very numerous at the first summit of the road and the rock forms the crest of the first main ridge. Between this and the second or main summit of the road, fossils may be obtained in considerable quantity, *Rhynchonella*, *Chonetes*, *Grammysia* and *Goniophora* all well preserved, having been obtained from a single block. *Ambocoelia* occurs in vast numbers, its casts forming the mass of several thin beds. From this summit to Kimberling creek, the road is in the shales and flags which are exposed almost constantly thence to the mouth of No-Business creek. The dip is steadily southward, but becomes comparatively gentle along the creek, being barely ten degrees at the mouth of No-Business. There Kimberling changes its course to south-east and evidently flows through Devonian to where it crosses the Saltville fault at two or three miles east from Mechanicsburg. The stream was followed only to within about four miles of the fault so that the limits of groups as given on the map are only approximate. Dismal and No-Business creeks, tributaries of Kimberling, take their rise respectively in Sugar Run and Pearis mountains, double outcrops of Medina with Clinton between the outcrops: but the streams

enter Kimberling in Devonian, which is the surface group in nearly all of the broad space between Brushy mountain at the south and Wolf Creek mountain at the north, the distribution being due to the disappearance of the Burk's Garden anticlinal and to the growth of the Kimberling anticlinal. The portion of the area lying north from Kimberling is almost uninhabited and is known as the "Wilderness."

Exposures are very indefinite along the Wilderness road for some distance from Kimberling creek on the way to Rocky gap; but near Mr. Benton's house, at, say, two miles from the creek, the rocks are dipping northward at nearly fifty degrees, and the rate increases at a little distance further, as is well shown by exposures in the stream.

The dip again becomes southward at somewhat more than a mile from Benton's house and the Chemung rocks are soon shown with almost vertical dip forming an irregular broken ridge. No exposures aside from those of a few dark shales occur in the interval to the next ridge, a space which should be occupied by Hamilton. A sandstone ridge, evidently Oriskany, is cut by the road at somewhat more than a mile and a half from the Rocky gap by which Wolf creek passes through Wolf Creek mountain, the same with that known in Tazewell county as Rich mountain. This ridge is cut by the creek at, say, three-fourths of a mile from the forks of road at head of the gap. No fossils were observed in the sandstone. Some white chert which may represent the Lower Helderberg was observed here.

The Clinton is quickly reached with its dark red sandstone; it makes a well-marked ridge and terrace along the southerly foot of Wolf Creek mountain. Fossil ore occurs very abundantly, but the fragments seen along the foot of the mountain are very silicious. Medina is shown in the stream-bed at the very head of the gap, whence it rises rapidly to crest of the mountain with a dip of twenty-five to twenty-seven degrees. The immediately underlying red beds are more silicious than at most of the localities visited, and they are exposed to a thickness of about 250 feet. Exposures are very indefinite beyond this until the Trenton is reached midway in the gap. The Calciferous beds next come up and at the mouth of the gap they are dipping southward at thirty-five degrees. These beds prevail to the cross-roads at J. D. Honaker's store.

Wolf creek bends northward immediately below Honaker's store and soon crosses the Wenonah fault, which brings Calciferous against Clinton, the dip of the latter being eighty degrees. The Medina caught in this double fault forms the Valley ridge, which is persistent thence to the New river. The creek passes through this ridge at say a mile and a half below Honaker's and affords a fine exposure of Medina on the easterly wall of the gap. The Calciferous limestones are reached immediately behind the ridge and within one-fourth of a mile are faulted against the Medina of Buckhorn mountain, a low ridge following the southerly foot of East River mountain. The road crosses this fault to the Medina, but returns to the limestone on the hill opposite Mr. Carpenter's house about

three miles from J. D. Honaker's store. Thence to New river the road is in the limestone between the two faults. The creek approaches the Buckhorn fault very closely near the line of Giles county, but the Wenonah fault, whose course is marked by the Valley ridge, is touched nowhere by Wolf creek below the gap near Honaker's. The dips in limestones between the two faults vary greatly, being from fifteen to forty degrees along the creek; but the rate diminishes toward New river, where it rarely exceeds twenty degrees. Though underlaid by limestones and calcareous sandstones, much of this Wolf Creek valley is very poor. Great fragments of Medina are numerous and the disintegrated sandstone has contributed most largely toward formation of the detrital covering.

The valley between Buckhorn and East River mountains is reported to be "freestone." No examination of its structure was made, but there appears to be a synclinal here, in which case the surface rocks would be Silurian shales.

The valley is contracted near the mouth of Wolf creek and the locality is known as the "Narrows." The crest of Wolf Creek mountain is carried northward in a bold knob which overlaps the Valley ridge. Thence it recedes southward, limiting the broad deep valley of Mill creek, to return northward and form the bold knob of Pearis mountain. The point of this mountain is at about two miles from Pearisburg and there the Medina outcrop curves southward under the influence of the Kimberling anticlinal. The Valley ridge becomes indistinct where the fault is crossed by the pike near Wenonah station. Thence to Pearisburg the road lies in Calciferous and Trenton limestones. The synclinal north from the Kimberling anticlinal is crossed by the Dublin pike at the southerly end of Pearisburg and in this is the "Angel's Rest" or terminal peak of Pearis mountain. The outcrop of Medina climbs the anticlinal as the fold declines, crosses it at the head of Sugar run and then moves eastward along the southerly side of the anticlinal. It soon recedes toward the west as it ascends the weakening anticlinal of Sinking creek and finally disappears against the Saltville fault.* That fault is crossed by the Dublin and Pearisburg pike at a very little way north from Poplar hill, where the Trenton and Calciferous are in contact and the road passes into the Rich valley between Big Walker's mountain and the Saltville fault.

A road, leaving the pike north from Poplar hill and leading to New river at Scott's ferry, crosses the Saltville fault at four miles from the pike or at a little more than one mile by Walker's creek above Staffordsville. Erosion here, as on the pike, has cut away all rocks higher than Trenton limestone from the north side of the fault, but, within a short distance, the Medina appears again and forms Buckeye ridge, the northern boundary of Rich valley to and beyond New river. The dying away of the Walker's Creek anticlinal permits the Walker's Mountain outcrop of Medina to advance northward so that the valley is narrow near New river.

* This outcrop was not followed to the Saltville fault and the statement given in the text is based on the topography.

The many railroad cuts along New river from this gap northward to Big Stony creek exhibit the structure very well. Only Calciferous is shown under the Kimberling and Sinking creek anticlinals until the Wenonah fault is reached near the mouth of Big Stony creek, where one sees Medina. Thence to the foot of Buckhorn or Little mountain the limestone is exposed in cuts and less frequently in natural outcrops.

The surface of the area between Pearis and Sugar Run mountains on the westerly side, and the Salt Pond mountains on the easterly side of New river shows traces of erosion planes. The underlying rocks belong to the Calciferous, Trenton and Hudson, but the detrital coat is very thick and for long distances completely conceals the bedded rocks.

The Buckhorn fault is continuous eastward from New river certainly for twelve miles and the limestones of the Calciferous are exposed frequently along Big Stony creek. The fault runs along the face of Buckhorn or Little mountain, but what becomes of it or of the limestone valley just south from it was not ascertained as the creek was followed only for three miles from the river, but the valley appears to be continuous to the county line. Big Stony creek approaches very closely to the Wenonah fault at barely a mile from the river, where the limestone is turned up suddenly at forty degrees northward and Medina is shown in the hill above.

A road leading to Little Stony creek leaves this stream at rather more than two miles and a half from the river. The Medina of the Valley ridge is reached before one comes to the first house, being shown in place at a little way from the road. The summit of the ridge is about 600 feet above New river at Snidow's lower ferry and there the Medina is reached a second time. The rock is not shown in place, but the surface is covered with fragments of the sandstone which could hardly have come down from Butte mountain. The limestones are reached again as the road descends to a little stream and they are still dipping southward.

The Trenton shales and shaly limestones are shown on the next ridge, but the Hudson beds are shown only further up the ridge eastward from the road. The summit of the road, at approximately 400 feet above the river at Snidow's lower ferry, is covered with debris of Medina and this ridge is merely the termination of Butte mountain. The Pearisburg synclinal passes at somewhat more than a mile from Little Stony creek, and the northward dip is well shown on the road as it descends to the creek. The Trenton limestones form a bold ridge on the southerly side of the creek, the southerly wall of a deep gorge which has Butte mountain for its northerly wall. Medina forms the double crest of Butte or Big mountain. The northerly outcrop encroaches on the narrow strip of Cambro-Silurian between the mountain and the Valley ridge so that the two lines of Medina appear to overlap. The area of the lower rocks is certainly so narrow that it cannot be represented on the map.

The road to the Mountain lake leaves the pike at Doe creek, which it follows to very near the lake. The cherts of the Calciferous are exposed

at the pike and the axis of the Kimberling anticlinal must pass near the fork of the road. The Lake road winds up the mountain side and reaches the Hudson beds within two miles of the lake. The Pavilion Knob, just west from the lake, shows the red shales with *Rhynchonella* and *Ambonychia* half way up, while at the very top is a large Lingula in vast numbers associated with a *Modiolopsis*. Medina caps several knobs on the ridge between Doe and Little Stony creeks. The outcrops of that rock meet on the summit of the Kimberling fold at a considerable distance east from the lake and thence to the eastern edge of Giles county Big and Salt Pond mountains are covered by dense forest, through which no road passes.

The Mountain lake or Salt pond is at somewhat more than 4000 feet above tide and is three-fourths of a mile long by one-half mile wide, the measurements being extreme in each case. It occupies a great sinkhole, which, within fifty years contained only a small pond of water at the bottom of the depression, by which a farmer salted his cattle. In some way, the outlet of the pool became choked, and water from the adjacent springs accumulated until it overflowed the rim and discharged itself into Little Stony creek. The subterranean outlet may be opened again and the pond drained. The spot is very attractive, and at one time it was a popular resort.

The road to Newport winds along the side of Salt Pond mountain, descending rapidly after it passes the point of the mountain, which is in the synclinal between Kimberling and Sinking Creek anticlinals. The Trenton shales are reached at about three miles from the Lake hotel and are thrown into numerous and complex folds, many of which are broken and slightly faulted along the axial plane. These occupy the synclinal and exhibit conditions the same with those observed in these shales in the Pearisburg synclinal on the point of Butte mountain. The massive beds of the Trenton are reached quickly after the road begins direct descent to Sinking creek, but exposures soon become rare, as the surface is thickly covered by debris, derived largely from Medina, of which huge fragments are numerous. The Calciferous cherts are shown occasionally, but not in place.

The Sinking Creek anticlinal is crossed at not more than two-thirds of a mile north from that creek, and the massive limestones of the Trenton are shown at the stream with southward dip. The pike is reached at a little way beyond the creek, and there the Trenton shaly limestones are shown much distorted and describing many complicated folds; the dip on each side being often eighty degrees. The thicker limestones are brought up several times. The road crosses the Saltville fault at a little more than half a mile north from Newport, the Trenton shales being brought into contact with the lower cherts of the Calciferous. The fault passes along Buckeye mountain, which, where crossed by the pike, has suffered much from erosion; but at a little distance on each side the Medina is present and the mountain is conspicuous. The Sinking Creek anticlinal diminishes eastward and the Medina outcrops unite before reaching the county line.

Rich valley widens between New river and Newport. The dips in its limestones are from fifty to sixty degrees. The massive beds of the Trenton are shown on Gap or Big Walker's mountain with this dip, and Medina at the summit shows a dip of sixty degrees. Exposures are very good on the northerly side of this mountain.

## IV. THE COUNTRY SOUTH FROM WALKER'S MOUNTAIN, EMBRACING PORTIONS OF WYTHE, PULASKI AND MONTGOMERY COUNTIES.

By far the greater part of Wythe county south from the Norfolk and Western railroad shows only rocks belonging to the Knox group, but the Potsdam is brought up along the southern border of the county, as well as at a little way from the railroad, in a bold east and west ridge, known as Lick mountain. In going southward from Wytheville, one finds the Knox limestones so much twisted as to suggest that the Draper mountain fault has not wholly disappeared. The Knox shales are shown within two miles from the railroad, where the road enters Lick mountain and the Potsdam beds at not many rods further. The sandstones of this great group form the hog-back ridges, of which the mountain is made up, while the shales are exposed in the deep ravines. The sandstones are passed at about eight miles from New river, where one comes again to the Knox shales, which are badly distorted.

On the road leading to the Wythe lead and zinc mine, which is reached at about two miles from Cripple creek, the rocks are concealed for long distances by the thick cover of terrace debris ; but the Knox limestones are well shown in the river bluffs, at the Wythe lead and zinc mine, both above and below Thorn's ferry, where the New river cuts a fine anticlinal.

The Wythe lead and zinc company have their mine at Austinville, in Wythe county, nearly seventeen miles from Wytheville, or twelve miles from Max Meadows station. The ore was discovered and first utilized not far from 130 years ago, but systematic mining has been prosecuted for barely fifty years. The reduction works have a capacity of between 600 and 700 tons per annum, and are of interest, as they were practically the only lead works within the limits of the confederacy and yielded nearly all of the lead employed in the manufacture of bullets for use of the Confederate soldiers.

The lead and zinc ores occur in an enormous impregnation deposit and are extracted both by open cut and by deep mining. The conditions in the surface workings are approximately as follows :

1. Gray limestone.....25′

   The upper part shows a network of galena ; some excellent blende almost free from galena is found midway ; while lower down both galena and blende occur abundantly. The lower half of the rock, which had been digged extensively, is said to contain a large amount of both blende and galena ; but it was concealed by a slide at the time of examination.

2. Gray sandy limestone.....10′
   This appears to be barren.
3. Ore.....8′
   This consists of carbonate and silicate of zinc associated with much galena. The calcareous matter has been leached out and the ore is in irregular honeycomb masses.
4. Limestone, evidently barren.....9′
5. Ore.....8′
   The conditions are the same as those in No. 3.
6. Limestone, gray.....25′
   This contains a very large amount of blende and galena, but the ore is not sufficiently concentrated to make working profitable.
7. Ore.....2 to 10′
   The conditions in this are the same as in Nos. 3 and 5. The deposit shows more irregularity than was observed in the others.
8. Limestone, apparently barren.....10′ to 12′
9. Ore.....6′ to 10′
   Here too the calcareous matter has been removed and the ore, which consists of zinc silicate and carbonate, with only a trace of galena, is cavernous.
10. Limestone, barren, seen.....5′

No further exposures occur. The upper edges of the limestone in this extensive stripping are rounded as though they had been exposed to long erosion, and the whole was covered with a tough reddish clay, fifteen to thirty feet thick, overlaid by slidden material, ten to twenty feet thick. For the most part the clay is barren, but sometimes it yields fragments of galena and altered zinc ores; and at a cutting just beyond No. 10 it has yielded a very considerable quantity of earthy carbonate of lead. These silico-carbonate ores are merely superficial, for at less than 100 feet from the surface in No. 9 blende occurs to the almost complete exclusion of calamine and smithsonite.

Though commonly spoken of as "leads," these deposits have no features entitling them to that name. The characteristics are well shown in surface workings made on this property by J. S. Noble in 1866, when he mined the zinc ore for shipment to New Jersey. These pits, at say half a mile from the tipple of the present surface workings, are on Bald hill, where erosion has removed the superficial material so as to expose the limestone over many acres. As the lease under which the work was done was short and as lump ore alone was to be removed, the deposit was worked only where richest and most distinctly marked; when it became indefinite the pit was abandoned and a new opening was made elsewhere. The whole area is pitted and the openings vary greatly in shape. Clearly no

systematic mining is possible in deposits such as this, and the only available method is follow ore, wherever found, until it ends.

The separation of the lead and zinc ores is effected by jigging. The ore, after crushing and grinding, passes to the jigs, which are in sets of four. The galena is almost wholly removed in the first, while the ores of zinc are separated by the remaining three. The separation is almost complete and the amount of escaped ore passing off in the tailings is insignificant. Much of the lead produced here is manufactured into shot of decidedly excellent quality, and an air-shaft, 262 feet deep, is utilized as the shot tower.

Along the road leading from Thorn's ferry to the Valley pike, exposures are few until Mr. Raper's house has been reached, but thence to the pike exposures are good. The Knox limestone is shown in the road near Mr. Raper's house and at a little way further the shales are at the surface. But a slight fault exists here, for the limestone re-appears within a few rods and continues until a short distance beyond the road leading to Walton's furnace. Thence to the pike the road lies in the shales and the Potsdam of Lick mountain nowhere reaches it. The beds seem to be thrown into two anticlinals, of which the more northerly is crossed near the last fork in the road, less than two miles from the pike, which is reached at barely seven miles from Wytheville.

Knox limestones, dipping west of north at sixty-five to sixty-seven degrees, are well exposed in Wytheville along the street leading from the railroad station to the court-house ; but exposures are very poor for some distance northward from the borough on the Wythe and Tazewell pike. The dip is soon changed on that side and the first good exposures show the south of east dip practically the same as the opposite dip on the other side of this Wytheville trough. The ridge on which the borough of Wytheville stands marks the course of the synclinal, which is cut off by the Max Meadows fault at a little way further east. The anticlinal north from this, in which the Max Meadows fault may originate, has been crossed before one comes to the blacksmith's shop two miles and a half from the court-house in Wytheville, for there the dip is northward at from twenty-five to thirty degrees ; but the place of the axis cannot be determined easily as the surface is covered with a thick coat of sands and clays.

The dip is changed again at somewhat more than two miles and a half from Stony Fork of Reed creek, the southerly direction being very marked at the S-curve in the road, while at Mr. Brown's house it is fifty-five degrees almost east of south. This direction of dip continues to the little valley in front of Stony Fork M. E. Church, where the Walker Mountain fault is crossed and one comes to the Umbral shales. The Knox limestone is well shown in the low hill, while shales are seen at its northerly foot dipping toward the fault at from thirty to thirty-five degrees. The shales are exposed occasionally at the roadside, and one comes to the silicious limestone at the Vespertine ridge, which forms the foothill of Little Walker mountain. The coal-bearing group begins below this limestone and its

red or brownish-red sandstones are shown for some distance southward from the ford.

Col. J. T. Boyd of Wytheville has opened several of the coal beds alongside of the stream as well as in a hollow coming down by Mr. Davidson's house. The numerous openings on the south side of the creek show fairly well the relations of the lower beds, the following section having been obtained:

1. Coal bed, V, said to be.....1′ 6″ to 2′
2. Interval, said to contain Coal bed, IV, 2′.....67′
3. Coal bed III, said to be.....1′ 7″
4. Sandstone and shale.....13′
5. Coal bed II, said to be.....6′ or more to 2′ 6″
6. Sandstone.....17′
7. Coal bed I..... 0′ 10″
8. Sandstone, seen about.....20′

Mr. C. R. Boyd, who has reported on this property, says that the interval, No. 6, becomes thirty feet at only a few rods from the locality visited. Coal beds II and III have been opened in a hollow above Mr. Davidson's house, where both are badly crushed, the lower much more than the upper. The roof shales have been crushed as badly as the coal at most of the pits, but at one under the road and alongside of the creek a fragment of *Lepidodendron* was seen, altogether without distortion; at all other points, however, the crushing and consequent distortion have practically destroyed all details of structure. The underclays are full of leaves or appendages belonging either to *Lepidodendron* or to *Stigmaria*.

The coal bed, II, has been opened at several places along its outcrop east from the creek, where it shows material variations in thickness and structure, due evidently to the pressure which the bed has undergone. The thickness at one opening appears to be more than four feet, but the structure could not be made out. A new cut showed

1. Black shale and coal streaks .....1′ 6″
2. Clay.....1′ 0″
3. Coal .....2′ 6″

Here there is apparently no distortion, but the crushing is no less severe than at an older pit where the bed has been twisted beyond recognition. The coal occurs in thin laminæ, easily separable and beautifully polished.

The "Quarry rock," the lowest bed of the Vespertine, which comes to the creek at the coal pits, is a gray, sometimes slightly conglomerate sandstone. The Chemung is not well shown in the gap through Little Walker mountain. The relation of Devonian to Upper Silurian is not altogether clear, as the Oriskany was not recognized in the "Poor Valley." Black shales, dipping northwardly, were seen nearly opposite Mr. Hedrick's house, which seem to be continuous thence to the final crossing of the stream, where they are associated with drab and yellow shales which contain fossil ore and are of Clinton age. From that place, the road winds for

three or four miles up the side of Big Walker mountain and for certainly half the distance is on Clinton which is thrown into many narrow folds. Where the Medina is first reached, the dips vary from fifteen to twenty-five degrees, but the rate increases, until at the summit the lower beds with *Arthrophycus harlani* dip south-eastwardly at forty degrees. Another form, like a *Scolithus*, penetrating a layer about ten inches thick, is seen at the summit. It is single at each surface of the layer, but forms a loop in the body of the rock.

The Vespertine beds form a foothill to Little Walker mountain and are faulted against the Lower Silurian rocks in Crockett's Cove of Wythe county as they are on Stony Fork of Reed Creek. But the Max Meadows fault crosses the strike and the eastern side of Wythe county shows a much longer continuous section than is found in the western part. On the southerly side of Crockett's cove the Trenton and Hudson beds pass upward into the short but bold Medina ridge known as Cove mountain, which is a notable feature of the scenery. Clinton forms the southerly flank of the mountain as well as the northerly side of the valley between Cove mountain and Max Meadows or Tract mountain, which lies north from the railroad between Max Meadows and Pulaski. The southerly side of the valley is occupied by Devonian shales passing upward into hard sandstones of the Chemung, which make the body of the mountain.

In following the Norfolk and Western railroad from Wytheville station eastward, one finds the north-westward dip continuous until the Knox shales are reached at about three and a half miles from Wytheville. Beyond that, exposures become few, but the road follows closely the line between the limestone and the shales until the Max Meadows fault has been reached beyond Max Meadows. Exposures are good and almost continuous between Max Meadows and Pulaski.

Some dark shales and impure limestones are exposed immediately beyond the former station and red shales are shown at and beyond the first small bridge. These are succeeded in the first cut by the dark limestone with veins and pockets of white spar, which lies at the base or nearly so of the Knox limestone. Owing to the direction of the railroad, this limestone is exposed until nearly two miles from Max Meadows. In a deep cut beginning there, the limestone has been replaced by a conglomerate, which may be of recent origin. It is not less than forty feet thick, has no definite bedding and is variable in composition, some parts breaking down readily on exposure, while others retain their shape and disintegrate very slowly. This may mark the course of an extinct stream.

The next cut, beginning at two and a half miles from Max Meadows, shows first a gray sandstone, quartzite-like in fineness of grain, which is succeeded by irregularly bedded reddish shales with thin streaks of sandstone, the dip being south-eastward at about fifteen degrees. The shales in the next cut are very red and somewhat fissile. These continue to Clark's Summit cut, which begins at somewhat more than four and a half miles from Max Meadows, where they are succeeded by reddish sandstone

and shales containing a thin coal bed. These have been thrown into petty folds and the coal bed has been the chief sufferer. It has been squeezed beyond recognition as a bed and the coal is laminated; but the lamination, unlike slaty cleavage, is rudely parallel to the plane of bedding.

The rock exposure ends abruptly midway in this cut and thence to the end, fully one-eighth of a mile, the material is a loose incoherent mass of clay and sand, loaded with fragments of sandstone, chert and a little limestone, all of the fragments being angular. This accumulation bears much resemblance to those containing "wash ores" in Bedford county of Pennsylvania. The limestone at the top of the Vespertine is shown in this cut very near the beginning of the rubbish.

The next cut shows the Vespertine rocks with a thin coal bed and with gentle dip. Some prospecting pits were sunk on the Clark property in search of coal, and, according to the report made to the writer, coal of fairly good quality was found in quantity to repay working; but no attempt to utilize the deposit has been made. The coal in the cut is too thin to be of any value, but the Hon. J. S. Draper states that beds of workable thickness occur on his property at a little way south.

It is sufficiently clear that the Max Meadows fault is crossed at not far from three and a half miles from Max Meadows, and that the red shales in the cut west from Clark's summit belong to the Lower Carboniferous.

Vespertine sandstones remain in sight to the Bertha Zinc Works, just west from Pulaski. Near the 86th milepost, or somewhat more than six miles east from Max Meadows, the blue sandstone is reached. This handsome stone has been quarried for building purposes; it has been used largely in railway masonry, and is the stone of which the Maple Shade Inn at Pulaski has been built. The rock is blue, fine-grained, cross-bedded and breaks with a conchoidal fracture. Where first seen it is exposed to a thickness of about twenty-five feet and contains many rounded balls of red clay or red shale scattered throughout the mass of the rock. The lower layer is less coarse but contains small pebbles of quartz and sandstone. No fossils were observed at any of the exposures.

This rock is shown along the railroad and Peak creek, forming bluffs alongside of the creek, and being quarried at several places on the railway. The thickness is not less than forty feet. Underlying it are shales and sandstones, the shales drab, gray to red, while the sandstone very closely resembles the more massive beds above. Some fucoids were seen in the red shales, but no other forms were observed.

The synclinal between Peak hills and Draper's mountain is crossed by the railroad at the tunnel near the second bridge over Peak creek, where the north-westward dip is twelve degrees. The sandstones of the group form a line of hills south from the railroad which are distinct from near Clark's summit to certainly two miles beyond Pulaski. The railroad runs on the easterly side of the synclinal to the Zinc Works. Between those works and the station passes the Pulaski fault, which brings the Vespertine into contact with almost the lowest bed of the Knox limestones.

Returning to Wytheville and taking the macadamized road leading thence to Newbern, one rides on the lower limestones of the Knox group until he crosses Reed creek, where the Knox shales are shown, still dipping sharply toward the west-north-west. The first good exposure beyond the creek is at the roadside near Kent's mill, where the limestones are shown with vertical dip, so that the axis of the anticlinal must pass at but a little way from the creek. The dip gradually decreases and within half a mile the massive limestones are dipping at from twenty to twenty-five degrees almost south-east. These limestones belong to the upper part of the Knox.

Half a mile further east, there being no exposures in the interval, Knox red shales were seen with almost vertical eastward dip. An exposure of sandy limestone, also with nearly vertical dip, was seen on the northerly side of the road at a little way further east, but thence the exposures are poor for several miles. The dip is reversed again near the Max Meadows road.

Where the road leaves Reed creek, at nine or ten miles from Wytheville, there is a close anticlinal whose formation was connected with severe disturbance, for the rocks are much crushed and there seem to be some petty faultings. The road turning southward soon rises to near the summit of the Lick Mountain anticlinal and follows it for a number of miles. The rock exposed for a long distance is the same limestone with veins and pockets of white spar, which is so well shown in the railroad cuts east from Max Meadows. It is associated with yellowish shales which are especially well shown in the cuts beyond the Pulaski road.

The chert ridge is double in the synclinal between the Lick Mountain anticlinal and Draper's mountain, and it forms an imposing knob near Reed creek, while one side of it forms a low persistent ridge between the pike and Draper's valley, terminating in a double knob at the eastern end of the mountain. This ridge is notched by many little streams which rise in the valley and unite to form larger streams only after passing through the ridge.

The Pulaski road leaves the pike at about twenty miles from Wytheville and crosses Draper's mountain. As it passes through the ridge of Draper's valley it shows the Knox limestones with easterly dip. The limestones end at a little way east from Mr. J. S. Draper's house, which is on the Knox shales. There the road begins to ascend the mountain and within a short distance sandy shales or shaly sandstone of the Potsdam is imperfectly exposed at the roadside. The next exposure, beginning at somewhat more than half a mile from Mr. Draper's house, is continuous to beyond the summit. This shows Potsdam sandstone dipping south-eastward at from thirty-five to fifty-five degrees, the average being not far from forty-five degrees. No fossils were observed in this sandstone, but the rock bears close resemblance to the Potsdam of Lick mountain as much in the intercalated brown or reddish-brown shaly beds as in the sandstone itself. There is nothing on either side of the mountain to answer to Hud-

son or Clinton, but on the northerly side is a mass of shale like that forming the lower part of the Potsdam on Lick mountain.

These underlying shales are well shown on the northerly side of Draper's mountain, where, for a few feet directly under the sandstone they are almost black; but for the most part they are grayish, sandy, and in rather thick layers, so that they might almost be termed shaly sandstones. Their south-easterly dip is as abrupt as that of the sandstone on the other side of the summit.

The Draper Mountain fault passes about one-third of a mile west northwest from the crest of the mountain, and on this road brings the lower beds of the Potsdam into contact with the lower Chemung shales. The Chemung sandstones form a bold ridge beyond the old Pepper road, in which the brownish beds contain many fossils. The Chemung conglomerate was not seen in place as the foliage was very dense, but its fragments are numerous. Vespertine beds form the next, a low ridge in which traces of coal have been observed and the bluish sandstones have been quarried. Thence for a little way there are no exposures, but in the bank behind the Maple Shade Inn the veined limestone of the Knox group is quarried, while just beyond Peak creek, immediately north from the railroad station in Pulaski, limestone belonging to the same group is exposed. These limestones are shown on the country road to the Robinson tract, a distance of about six miles, and that beautiful tract must also be underlaid by the Lower Silurian limestone; but no examination to ascertain this was made.

The limit between the shales and shaly sandstones of Devonian and Carboniferous at the west and Lower Silurian at the east was not followed out in detail, but it passes almost midway between the Altoona coal road and the county road in Pulaski; it is a little way west from the Poplar Hill church, four or five miles from Pulaski. Beyond that northward, it evidently lies east from the Altoona railroad.

The Altoona coal mines are in Pulaski county, at eleven miles by rail from Pulaski, though the actual distance is much less. The bed now mined is the second of the Vespertine beds, which varies in thickness from four to twenty-two feet, in the latter case including not a little shale. The pressure has crushed the coal to such an extent as to destroy in great measure its marketable value, but a large quantity is mined each year for use at the Salt works in Smyth county. At one time the third bed, said to be four feet thick, was mined here, but work on it has been discontinued, only a small quantity being taken out to run the locomotives on the coal road. The coal from this bed is far superior to that from the other.

A road follows the bottom of Peak creek for nearly two miles below Pulaski, and then leaves the creek to cross the easterly point of Draper's mountain to the Valley pike, which it reaches at somewhat more than a mile and a half southward from Peak creek. The Vespertine ridge is cut off by the Pulaski fault before this road reaches the line, but the Devonian ridge continues beyond the road. The Draper Mountain fault is greatly

diminished in strength and the Potsdam sandstone makes little showing along this road. That rock evidently extends to near Peak creek and the limestone on the north side of the Pulaski fault must be in contact with it near the creek.

Where the road reaches the pike, Knox shales are shown at the roadside with almost vertical dip. For the most part they are red, weathering dark brown and covered with lichens. With these are some yellow and blue shales, and streaks of impure limestone. The shales continue along the pike to beyond Peak creek, where one crosses the Draper mountain fault and comes again to the Knox limestones. An anticlinal was observed in Newbern, the county seat of Pulaski county. Thence to half a mile north from Dublin the limestones are dipping northwardly.

But a little more than half a mile north from Dublin, exposures practically cease and thence almost to Back creek very little is shown. The whole space is an old erosion plane and the bedded rocks are concealed under a deep cover of debris. The few imperfect exposures show only shales, which are dipping southwardly. These belong to the lower part of the Knox limestone and are the same with those exposed on the valley pike, east from the Pulaski road. Limestones are reached near Back creek and continue to perhaps half a mile or more north from that stream. The beds appear to be wholly without fossils, but their relations are clear enough and they belong to the lower part of the Knox limestone. The lowest bed is the dark limestone carrying veins and geodes of white spar, which is exposed for a long distance on the Valley pike, east from Reed creek.

After crossing Back creek, the road begins to ascend Cloyd's or Little Walker mountain and exposures are good. A great thickness of red shales comes immediately behind the geodal limestone and some of the upper beds are very like those of the Knox shale; but shales of very different character are soon reached, which belong to the Lower Carboniferous, to the Umbral period. The Vespertine or coal-bearing division is reached at a short distance below the Jennell place, where one of the beds has been mined to some extent. The blossoms of four beds are shown in the roadside, above the Jennell house, within a vertical distance of about 115 feet. The upper beds are not more than three or four inches thick, but the second is almost nine feet from rock to rock. It is said to contain one foot of good coal at the bottom, while the rest of the interval is occupied by alternating thin layers of coal and shale. The lowest bed is from two feet to two feet six inches thick, and is said to yield very good coal. This is said to be the bed worked by Mr. J. H. Tyler, two miles east from this road. That mine was not visited. The interval between the two beds at the roadside is about fifteen feet and is filled mostly with sandstone.

The lowest bed of the Vespertine is a gray sandstone, well-shown at the roadside. The passage to the Chemung is imperceptible through concretionary sandstone and shale, undoubted Chemung being reached in a fossiliferous sandstone containing *Chonetes* and other forms which are not

recognizable on the weathered surface. Concretionary sandstones continue below this and, at say 300 feet lower in the series, the upper conglomerate of the Chemung is shown, with not a few of its layers containing flattened pebbles. The concretionary structure gradually disappears below the conglomerate and many of the beds on the northerly side of Cloyd's mountain are fossiliferous. The conglomerate forms the crest of the mountain for nearly the whole length. The variegated flags and shale in the lower part of the Chemung are reached quickly on the northerly side of the mountain as the road descends to the valley of Little Walker creek. Exposures are fairly good in the valley and in the gap through Big Walker mountain, but Oriskany was not recognized, so that, if present, it must be very thin. Medina forms the great part of Big Walker mountain and is fairly well exposed in the gap made by Little Walker creek.

The Medina is well shown in the gap made through Big Walker mountain by New river, where it appears to be in all not far from 375 feet thick. Good exposures occur here between the mountains, but, if present, the Oriskany and Lower Helderberg are so thin that they escaped observation. The Chemung beds are sufficiently well shown to make the construction of a complete section by no means difficult to one doing systematic work ; but no section was attempted by the writer, who began his examination near the top of the group.

The "point" of Cloyd's mountain in New River gap is at a little more than eight miles from New River station on the main line. There the Chemung conglomerate, which forms the backbone of the mountain, comes down to the river and is exposed in a railroad cut. Behind it for about 130 yards—beyond which no examination was made—fragments of the bluish-red sandstones of the Chemung are plentiful in the debris which covers the mountain side. Many of these fragments are fossiliferous and the locality will prove to be a good one for the collector. The sandstones are very hard and the fragments are used in ballasting the track from this place almost to New River station.

The upper conglomerate of the Chemung, as shown in this New River gap through Cloyd's mountain, is not far from thirty feet thick. Its upper part is well exposed, is about fifteen feet thick, very hard and coarse, with pebbles often as large as a hen's egg, mostly of quartz and frequently flat. In some of the layers the longer axis of the pebbles is vertical to the plane of bedding. The lower part is less hard, is conglomerate only in some layers and has a rusty color on the weathered surface. The dip is almost south-east at fifty-five degrees.

Ten feet of brownish sandstone are exposed at fifteen feet above this conglomerate, but no further exposure occurs in a horizontal space of about 1175 feet. Fragments with Chemung fossils are abundant in the first 500 feet of this interval, but beyond that they become less plenty and soon disappear, so that proof of Chemung is not likely to abound in the upper half of this interval.

The bottom of the undoubted Vespertine, the "Quarry rock" of Lesley

is exposed at the end of this interval. The exposure shows only five feet, but the fragments indicate a thickness of fully thirty feet. The rock is light gray, some parts are very hard and in thick layers, but others are in thin layers ; the dip is nearly fifty degrees.

This rock is succeeded by shales ill-exposed and extending nearly 400 feet to the eighth mile post. The exposure is so poor that the dip could not be ascertained, but it may be taken as averaging not far from thirty-five degrees. Here belong the coal beds, to which reference has been made, and one of them is mined on the opposite side of the river.

From the eighth mile post for 1175 feet, everything is practically concealed. Clearly enough the interval is occupied by gray to bluish sandstones and shales, but there is no exhibition good enough to tell the rate of dip. An uncertain measurement almost midway in the interval made the rate not far from twenty-five degrees. As the next exposure shows a dip of only fifteen degrees, the dip in this concealed interval may be averaged at twenty degrees.

This is succeeded by a reddish or bluish sandstone, forty feet thick, which is well shown in a cliff on the hillside but does not appear in any of the railroad cuts. The dip is fifteen degrees.

No further exposure occurs for 200 feet, beyond which comes a sandstone with dip of ten degrees. This is shown as a cliff, but it was not seen in the cuts ; it continues for a horizontal distance of 600 feet. The color varies from gray to rusty brown and the rock is fine-grained but irregular in bedding.

This is succeeded by a concealed interval of 375 feet, in which the dip is twelve degrees ; beyond it one comes to red sandy shale extending 300 feet with dip of twelve degrees. Upon this rests a red to gray, irregularly bedded sandstone continuing for 200 feet, also with dip of twelve degrees. After a concealed space of ninety feet, sandstone, gray to red, is reached, which, with dip of fourteen degrees, extends for 300 feet along the track. It contains many thin beds of red shale and some insignificant beds, or rather streaks, of impure limestone or possibly only calcareous sandstone. Above this are alternations of red sandstone and red shale, with dip of fifteen degrees and continuing for 2200 feet to Back creek just beyond Tyler's coal switch. Next comes the geodal limestone, to which reference has been made so frequently and which belongs at the base of the Knox limestone. Evidently the fault of Walker mountain has been crossed ; so the succession may be summarized. It is as follows :

*Lower Silurian.*

Limestone in bank of Back creek.....25′

*The Walker Mountain fault.*

*Lower Carboniferous.*

1. Red sandstones and shales.....570′
2. Sandstone, red to gray with some shale..... 73′
3. Concealed..... 23′

4. Sandstone, red to gray..... 42′
5. Red shales..... 63′
6. Concealed..... 78′
7. Sandstone.....105′
8. Concealed..... 42′
9. Sandstone, reddish brown to bluish..... 40′
10. Shales and sandstones.....400′
11. Shales with coal beds.....230′
12. "Quarry" sandstone..... 30′

*Devonian.*

1. Concealed.....900′
2. Sandstone..... 10′
3. Concealed..... 15′
4. Conglomerate..... 30′
5. Sandstones, flaggy, not well shown.....160′

The Walker Mountain fault passes very near the mouth of Back creek and is crossed by that stream at a little way west from the railroad. The exposure of the shales is practically continuous to the creek, but there were seen none of the yellow shales observed on the Dublin and Pearisburg pike. The line of fault is therefore drawn directly under the limestone of the Knox group.

Southward from Back creek for nearly a mile, the whole region near the railway is covered with a thick deposit of terrace debris, and the only exposure is in a cut at about 1000 feet from the end of the Back creek trestle, where a veined, somewhat brecciated limestone is shown associated with light drab shales, all belonging to the lower part of the Knox limestone. The next exposure is in a stream at, say, 600 feet south from Belspring station, where limestones and shales are shown. Similar beds are exposed on the railroad at about 300 feet further, where the shales, or rather shaly limestones, weather light yellow or grayish white. The limestone is drab to blue, is somewhat silicious, is veined with white spar and is more or less brecciated. The dip is south-eastward at about eighteen degrees. But the dip quickly becomes flexuous and these shales and limestones remain in sight to the fifth mile post. The irregular dip continues for half a mile further, but thence for a mile or two, to within three miles and a half of New River station, the more prevalent dip is south-eastward, so that the massive limestones with large nodules of chert are brought down. These thicker beds are separated by impure shaly limestones which weather into clays, usually yellowish red.

The dip becomes north-westward at three miles and a half from New River station, and this direction is kept for probably a mile along the road, which follows the strike for much of the distance. In the deep cuts about two miles and a half from New River station, the beds are in great disorder and consist of the shaly limestones which the reversed dip has brought to the surface again. Thence no exposure was found until the first mile

post was reached, where somewhat higher beds are shown in very confused stratification. From this place to the main line of the Norfork and Western railroad at New River bridge, the thick bedded limestones of the Knox group are bent and folded to a degree, which one would think hardly possible in rock of that character, yet so far as could be ascertained no fractures exist.

Returning to the New River gap through Walker mountain and crossing the river so as to take the road leading across Price mountain to Christiansburg, one comes to the Vespertine as the road rises to the river hill. But exposures quickly become indefinite and little is shown until beyond Price's fork in the road, about five miles west from Blacksburg. The only exposures in this interval of four or five miles are of drab shales such as were seen in the cut south from Belspring station on the New River branch of the Norfolk and Western railroad. The whole area for several miles from the river is covered with the terrace deposit, which is very deep. The Knox limestones are shown on the Blacksburg road, as well as to a short distance south from it, dipping southwardly; but a synclinal is crossed between that road and the northerly fault of Price's mountain, so that the limestones, where last seen, dip away from the fault.

Red shales of the Lower Carboniferous, such as those seen on New river, are shown on the flank of Price mountain, and are underlaid by the coal-bearing Vespertine. The coal beds are mined along a fork of Strouble's creek on the northerly side of the Price Mountain anticlinal. Several abandoned openings were seen on the Bruce property, one of which showed

| | | |
|---|---|---|
| 1. | Sandstone | not measured. |
| 2. | Clay | 0′ 5″ |
| 3. | Coal | 0′ 10″ |
| 4. | Slaty coal | 1′ to 0′ 10″ |
| 5. | Coal seen | 2′ 6″ |

The dip is northward at thirty degrees; the coal has been crushed badly but not so badly as in the mines of Little Walker or Brush mountain. The bed is mined by Linkous and Kipp at somewhat more than half a mile further west, where, according to Mr. Linkous, the lower part of the bed is

| | | |
|---|---|---|
| 5. | Coal | 2′ 6″ to 2′ 10″ |
| 6. | Coal | 1′ 3″ |
| 7. | Coal | 1′ 6″ |

No. 6 is soft and is used as the "bearing-in," but the others are very hard. The coal has been crushed to but a very slight extent in comparison with that on the other mountains. It bears much resemblance to cannel. It is mined extensively and is wagoned to Bang's station, whence it is shipped to neighboring stations.

The rocks alongside of the road dip at fifty-five degrees as the crest of the anticlinal is approached; but on the other side near Mr. Church's mine, the dip in the southerly direction is barely twenty degrees. Thence

nothing was seen aside from the shales and sandstones until the Blacksburg and Christiansburg road was reached, on which the southerly fault of Price's mountain was crossed at a little way north from Mr. Stevens's house, where Umbral shales and Knox limestones are in contact.

Directly north from Mr. Stevens's house, the road from the coal mines unites with that leading northward to Blacksburg and Newport. Exposures are very indefinite on this road as it crosses Price's mountain, though the Lower Carboniferous shales are shown in several shallow cuts. No coal blossoms were seen along the road and no coal is mined near it.

The Knox limestones are reached at somewhat more than two miles south from Blacksburg, but exposures on this old erosion plane are few and widely separated, so that nothing can be told respecting the character of the rocks.

The place of the Walker Mountain fault is about half a mile south from Tom's creek, where Umbral shales are thrown over to almost vertical dip, while the Knox limestones are shown within a few rods with much gentler dip. Coal is mined at several places on Tom's creek both above and below this road. The dip at a pit immediately south from the creek is twenty-five degrees toward the south-east. The bed is thin, being reported as follows:

| | |
|---|---|
| Coal | 1′ |
| Clay | 0′ 6″ |
| Coal | 1′ 6″ |

but the bed is thicker at other pits and, at some, it has three feet of workable coal. The crush has been severe and the coal of the Tom's creek mines is so loosely laminated that the laminæ are easily separated by the fingers.

The dip becomes gentler as the road ascends Brush or Little Walker mountain. Sandstones with dip of ten to twelve degrees make the roadbed for a long distance and form spurs extending southward from the mountain. The passage to the Chemung is through these yellowish sandstones, which appear to be thicker than on New river. The upper beds of the Chemung are not shown near the road; fragments of the upper conglomerate are numerous, but the rock was not seen in place. It however forms the crest of Brush mountain and Chemung fossils are numerous at several exposures on the northerly slope as the road descends to "Poverty flats," the "Poor valley" between the Walker mountains. The conditions in this valley, digged out of Chemung, Hamilton and Clinton shales, differ in no way from those in the "Poor valleys" already described. Exposures show nothing but shales.

The Clinton ore was mined here many years ago for the furnace at Newport, in Giles county, but nothing can be learned now respecting either its quantity or quality. Medina forms the southerly slope of Gap or Big Walker mountain and on the summit is dipping south-eastwardly at sixty degrees.